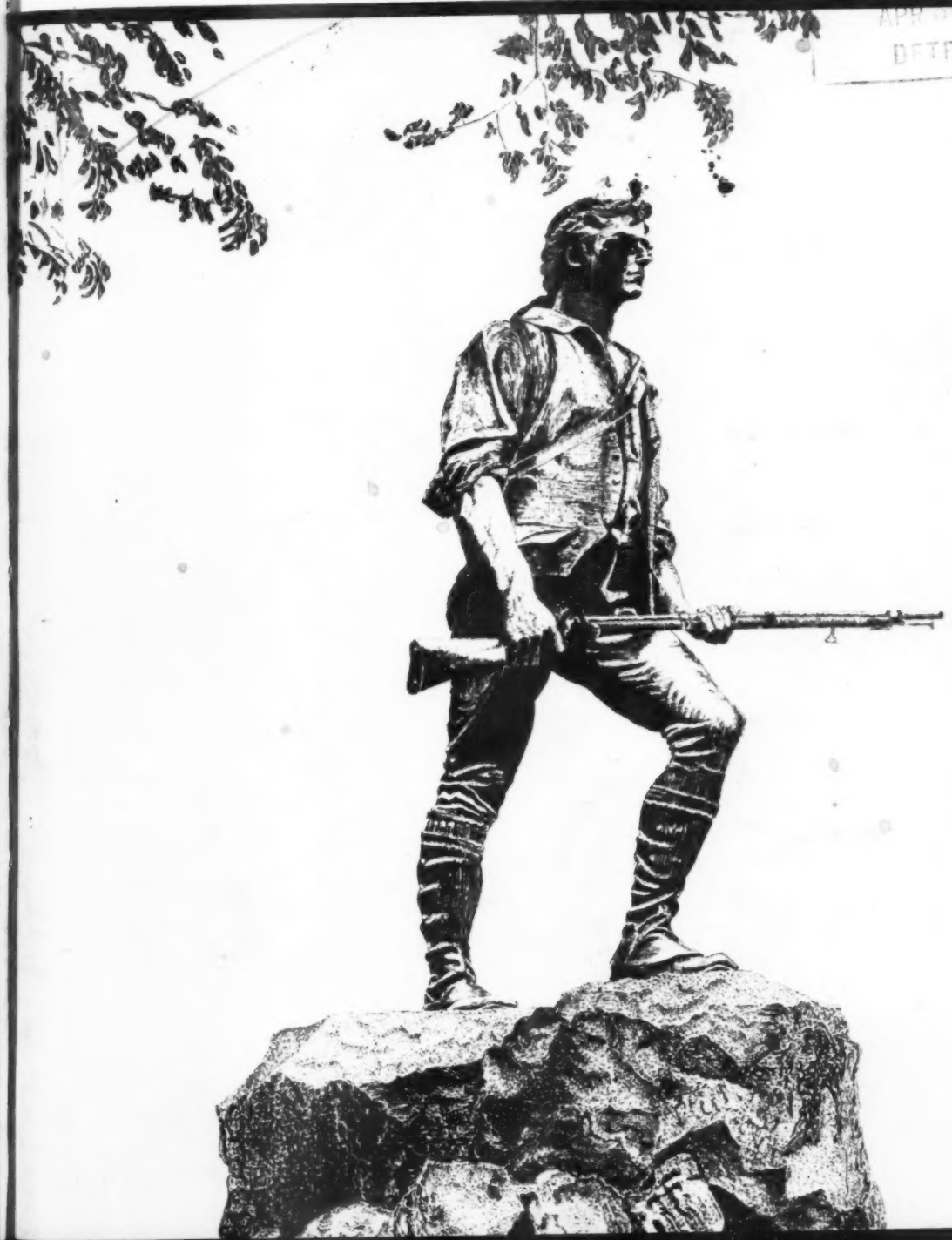
NOLOGY DEPARTMENT

April 1948

TECHNOLOGY REVIEW

Title Reg. in U. S. Pat. Office

PUBLIC LIBRARY
APR
DETROIT



ELIMINATE ASSEMBLIES
and
MACHINING COSTS
USE NON-FERROUS
FORGINGS
by
THE HARVEY
METAL CORPORATION
HAROLD B. HARVEY '05 • Engineers & Manufacturers • SHERRY O'BRIEN '17
74th STREET and ASHLAND AVENUE • CHICAGO 36, ILLINOIS
FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOYS
MACHINING FACILITIES

LIES
COST

MIT LIBRARIES
APR 3 - 1948
DETROIT

Why Pay This Unnecessary Expense in these Days of Rising Costs?

Unlike your other rising costs of production (in payrolls, machines and raw materials) the soaring cost of eye accidents is one expense you *can definitely do something about.* You can "roll back" this unnecessary cost 98% because eye accidents are preventable when shop workers wear safety goggles. The average cost of goggles is about $1.50 — even the *slightest* eye accidents they prevent average over $15.00. Your nearest AO Safety Representative can show you case histories of plants similar to yours where an adequate eye protection program has been *eye-opening* in costs saved!

American Optical — *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, April, 1948. Newsstand Edition. Vol. L, No. 6. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

"POLY-LITE"

EXTRUDED POLYSTYRENE SIDE SHIELDS BY SANDEE

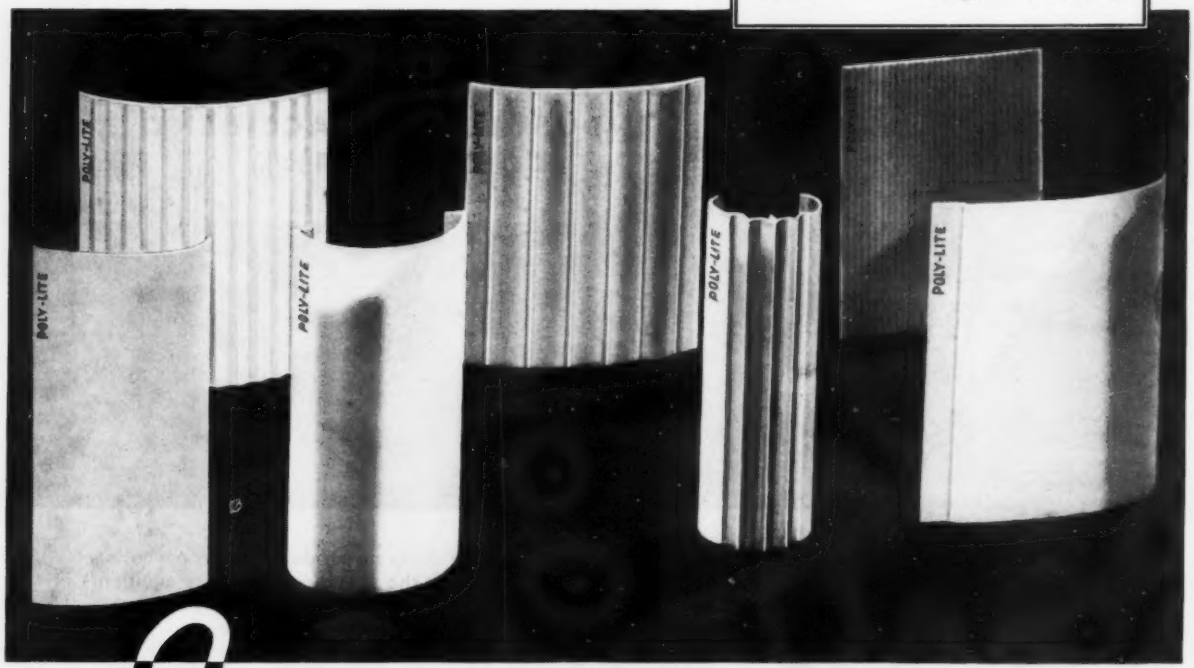
SANDEE chose "POLYSTYRENE" for the production of its "POLY-LITE" Fluorescent Light Sections because of its outstanding properties for this application. Study the properties listed here and you will agree that these features, plus Sandee technology, create a combination unequaled for the development of your new fixtures to give the maximum in aesthetic and functional lighting.

Sandee production experience plus the satisfaction of many customers verifies the choice of POLYSTYRENE for these Extruded Fluorescent Fixture Sections. This experience is available to you now without the necessity of an extended trial period—so contact *Sandee* on your new, modern highly efficient fluorescent fixtures.

"POLY-LITE" IS A GUARANTEE OF QUALITY

OUTSTANDING PROPERTIES OF SANDEE POLYSTYRENE

1. Specific Gravity	—1.05
2 Tensile Strength	—5500 to 7000 P.S.I.
3. Impact	—0.5 ft. lbs. (notched)
4. Heat distortion	—175°F
5. Rigidity	—Excellent
6. Dimensional Stability	—Excellent
7. Water Absorption	—Nil
8. Burning Rate	—Slow
9. Electrical properties	—Excellent
10. Odor	—None
11. Color	—Unlimited
12. Finish	—High Gloss if Desired



SALES REPRESENTATIVES IN 19 PRINCIPAL CITIES

Sandee Manufacturing Company

5050 FOSTER AVENUE • CHICAGO 30, ILLINOIS

EXTRUDED PLASTICS AND SPECIAL TOOLS

IEW

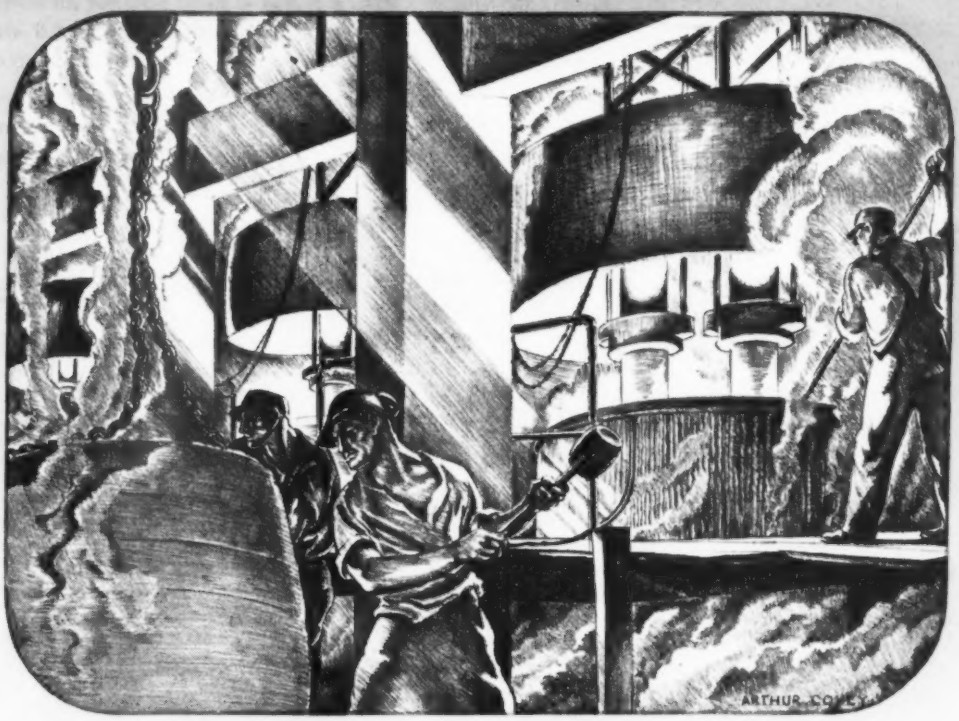
//

E

E S

Producing ALUNDUM®

the world's most widely used abrasive



IN these unique, arc-type furnaces at the Norton electric furnace plant near Niagara Falls is produced ALUNDUM abrasive — fused at 3700°F from mineral bauxite.

Introduced to industry by Norton in 1901 this first electric-furnace-made aluminum oxide abrasive revolutionized the grinding of steels because of its combination of hardness, sharpness and toughness.

Subsequent Norton developments were designated as 38 ALUNDUM and 57 ALUNDUM—and then in 1946 came the sensational 32 ALUNDUM abrasive.

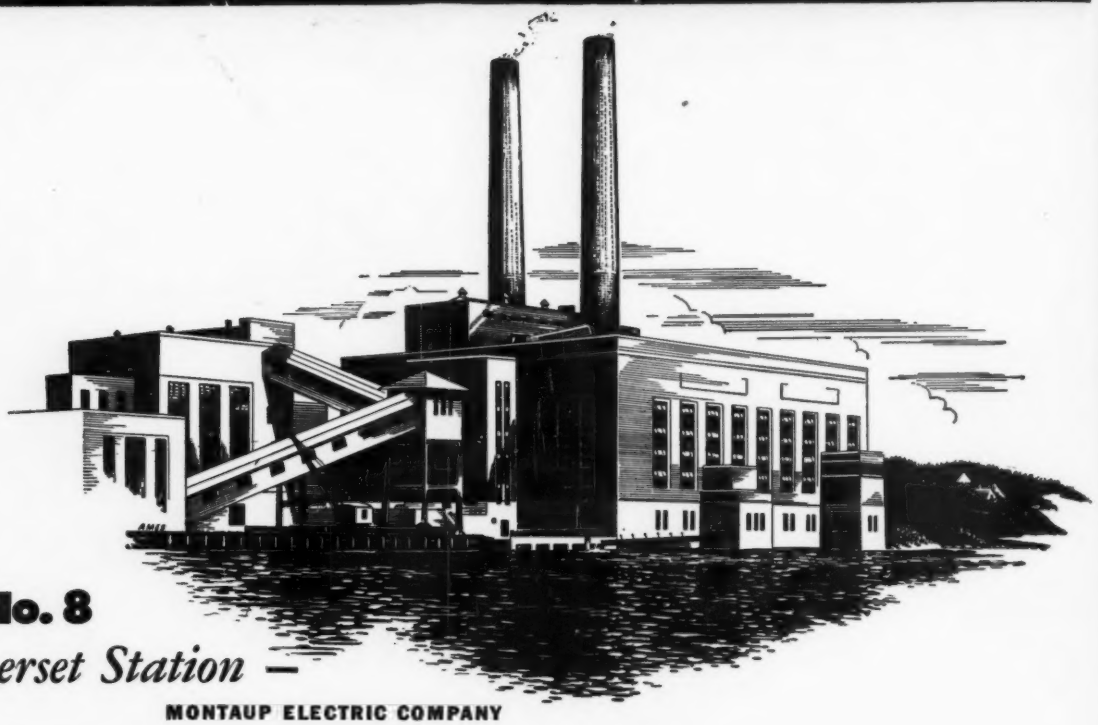
Today ALUNDUM abrasive in its various forms is the world's most widely used abrasive.

NORTON ABRASIVES

NORTON COMPANY • WORCESTER 6, MASS.
(BEHR-MANNING, TROY, N. Y. IS A NORTON DIVISION)

ABRASIVES • GRINDING WHEELS • GRINDING AND LAPPING MACHINES • REFRACTORIES • POROUS MEDIUMS • NON-SLIP FLOORS NORBIDE PRODUCTS • LABELING MACHINES • (BEHR-MANNING DIVISION: COATED ABRASIVES AND SHARPENING STONES)

History-making power stations



No. 8

Somerset Station —

MONTAUP ELECTRIC COMPANY

IN a very real sense Somerset Station is a pioneer in the utility field.

Progress in steam generation for public utilities has been almost wholly along the lines of improved designs of conventional types of equipment and the adoption of higher steam pressures and temperatures. But use of the basic principle of natural circulation of water in boilers has remained the rule in American power practice.

It was truly history-making then, when, in 1942, the Montaup Electric Company of Fall River, Mass., installed a radically different boiler . . . a *forced circulation* boiler in which the water is circulated by pumps instead of being allowed to follow its natural thermal circulation. The principle of forced circulation had been used commercially in Europe but in connection with boilers of smaller size. This was the first application in an American power station and had the further distinction of being the first boiler to produce steam at a temperature as high as 960 deg. Fahr. It was also one of the two highest pressure boilers in this country. A major advantage was the adaptability of the design to the available space which permitted substantially higher capacity than could have been obtained from a natural circulation boiler. Actually it was fitted into a space originally intended for a boiler with one-fifth of its capacity.

This drastic departure from conventional practice — watched critically by leading power engineers everywhere — required courage, because of the large financial risks, and engineering competence of a high order to solve the many technical problems. That Combustion Engineering, designers and builders of the boiler, the Montaup Electric Co. and their consulting engineers, Stone and Webster Engineering Corp., solved these problems has been demonstrated by the boiler's performance record over the past five years. Not only is it one of the most successful big boiler installations in the country, but it has proved that *forced circulation* affords important operating advantages for large power stations.

COMBUSTION ENGINEERING

200 MADISON AVENUE • NEW YORK 16, N. Y.

The association of C-E with Somerset and many other power stations that have made history speaks for itself. The experience, special skills and advanced engineering that have brought about these associations are available to you, whether you need a boiler to produce less than a thousand or more than a million pounds of steam per hour.

These three factors are the unwritten plus-values in every C-E contract —

Knowledge — *to solve today's, and tomorrow's, steam generating problems.*

Experience — *to interpret, from a world-wide background in every important industry, the specific needs of each installation.*

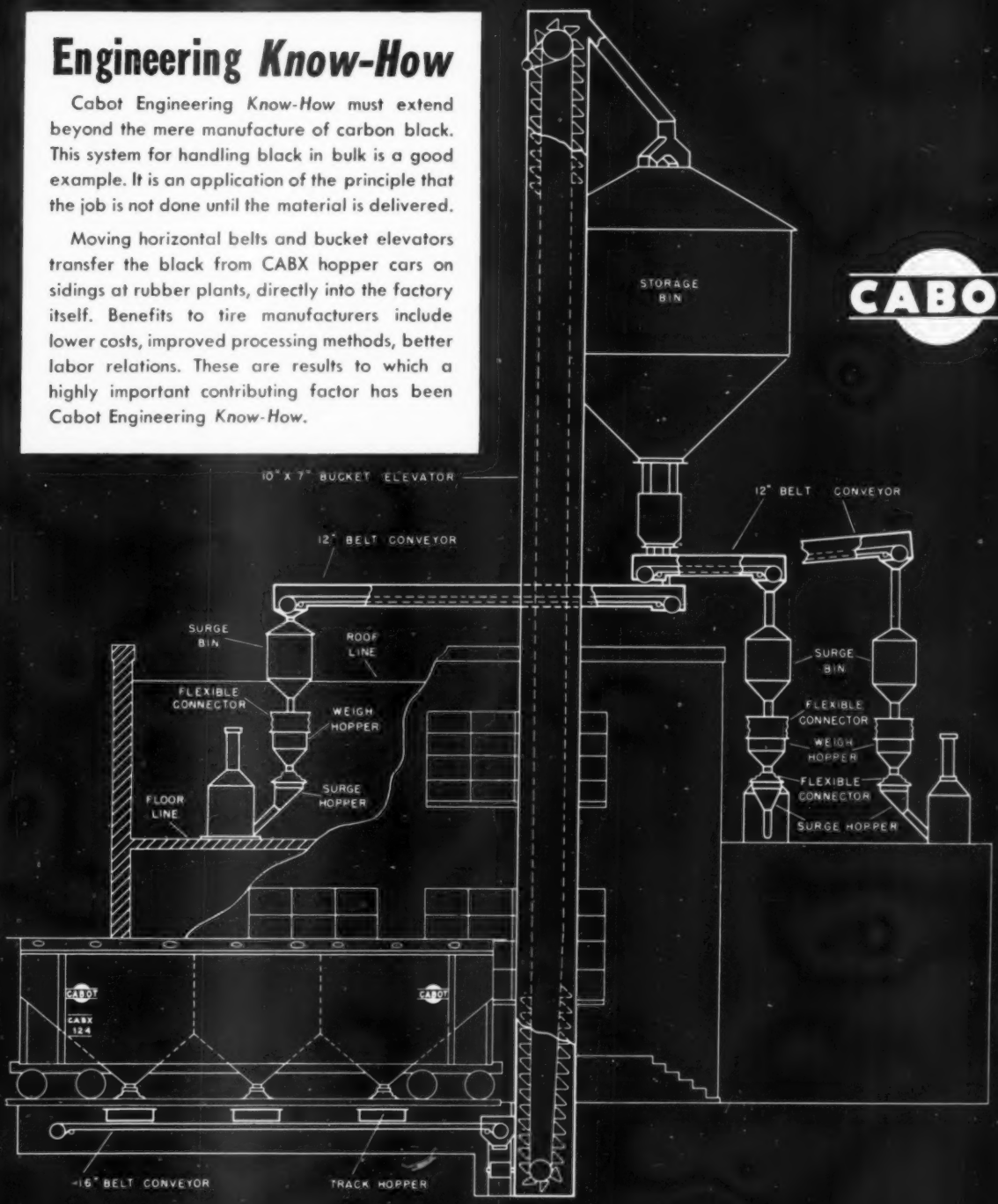
Facilities — *to manufacture complete steam generating units for every capacity from 1000 pounds of steam per hour up to the largest.* B-180

Engineering *Know-How*

Cabot Engineering *Know-How* must extend beyond the mere manufacture of carbon black. This system for handling black in bulk is a good example. It is an application of the principle that the job is not done until the material is delivered.

Moving horizontal belts and bucket elevators transfer the black from CABX hopper cars on sidings at rubber plants, directly into the factory itself. Benefits to tire manufacturers include lower costs, improved processing methods, better labor relations. These are results to which a highly important contributing factor has been Cabot Engineering *Know-How*.

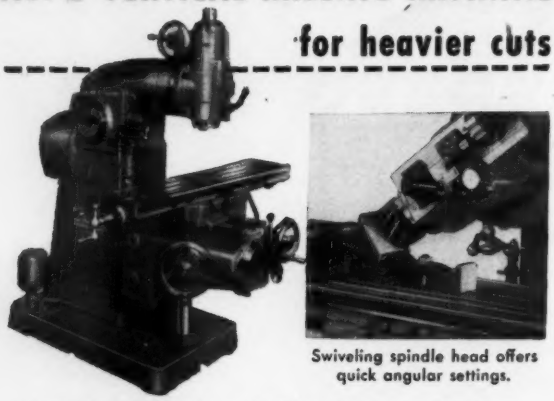
CABOT



GODFREY L. CABOT, INC.

77 Franklin Street, Boston 10, Mass.

NOW! A 5 HORSEPOWER
No. 2 VERTICAL MILLING MACHINE
for heavier cuts



Swiveling spindle head offers quick angular settings.

THIS NEW MACHINE embodies all the production-boosting features of the popular No. 2 Light Type machine plus extra power and rigidity for work requiring heavier cuts. In addition, it has greater throat distance, suitable spindle speeds for larger cutters and has many useful attachments.

For complete details on this new machine, write Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

BROWN & SHARPE

HEVI DUTY

Hevi Duty Electric Co.
Surges Transformers

With the acquisition of the Surges Electric Company of Milwaukee, Hevi Duty can now offer quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements. An accelerated program of modernization will present opportunities for increased production and good delivery schedules.

Write for Bulletin S-4611

HAROLD E. KOCH '22, ***President***

ELTON E. STAPLES '26, ***District Manager, Cleveland***

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

THE TABULAR VIEW

Minute Man. — The pen-and-ink drawing of the Lexington Minute Man, which graces The Review's cover this month, appropriately commemorates the events of Lexington and Concord in April, 1775, when "embattled farmers . . . fired the shot heard round the world." The appropriateness of the April cover is further enhanced by the fact that it was executed by able artist SIDNEY L. KAYE, '30.

Workman's Slant. — Well known to Review readers for his able commentaries on the social effects of modern industrial life, Dr. Paul Meadows attempts to answer the question "What's on the Worker's Mind?" (page 322) by a descriptive summary of public opinion polls, chiefly those of Roper, Gallup, and polls reported in *Public Opinion Quarterly*. Dr. Meadows is associate professor of sociology at the University of Nebraska.

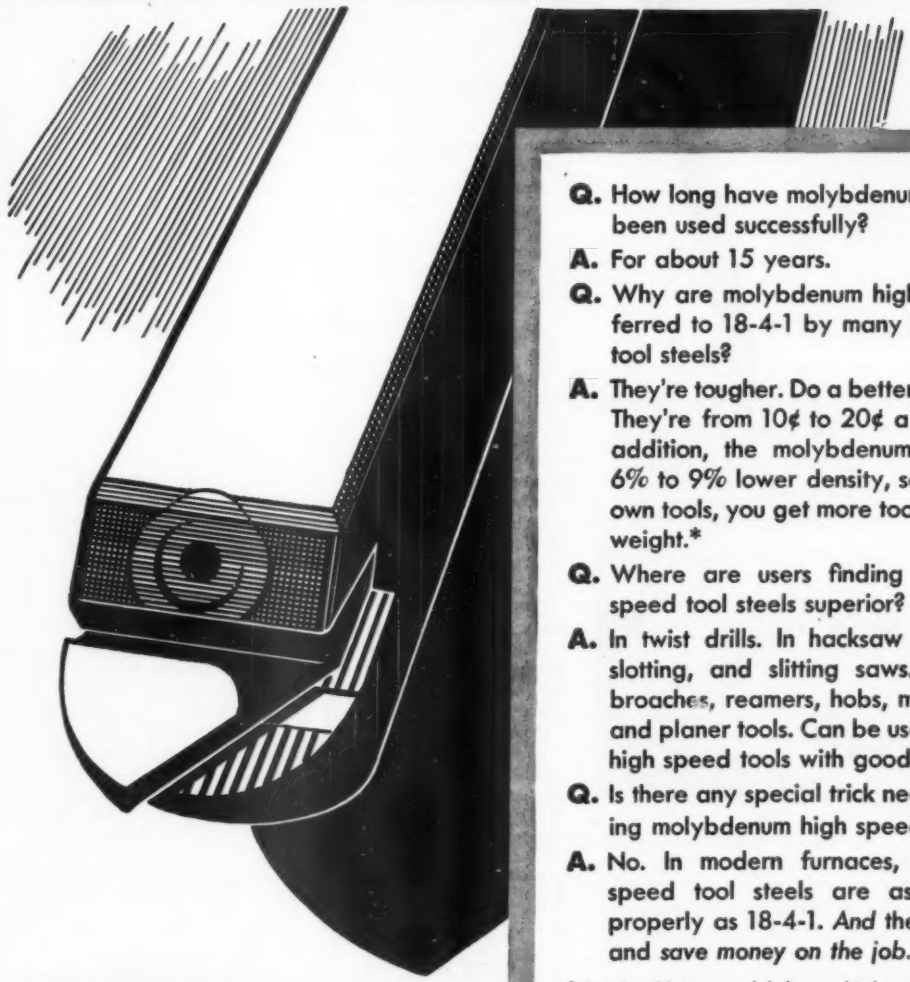
Revolutionary Mathematician. — The story of Évariste Galois is that of a brilliant Frenchman whose outstanding mathematical work was prematurely ended at the age of 20. The biography of this unheralded mathematical genius is ably recounted (page 316) by DAVID AND CHARLOTTE B. LANDAU. The Galois biography is the product of a happy collaboration of an engineer, specializing in stress studies and elastic theory, and his wife, a teacher and writer on scientists and scientific matters, who is, as well, a graduate in science from French schools.

Daily Hibernation. — Any interested observer is able to determine by experiment the individual factors which go to make sleep such an important and pleasant part of our daily lives. To such lay observations the authors of "Ah, Sweet Mystery of Sleep" (page 319) add a distinctly professional touch. DR. M. F. ASHLEY MONTAGU, already known to Review readers through his articles on matters relating to medicine, is associate professor of anatomy at the Hahnemann Medical College and Hospital of Philadelphia. He is assisted in his professional work by coauthor EDWARD MILTON, member of Harvard's class of 1933 and a former major in the United States Army.

Quantitative Biology. — Perhaps the "numbers racket" does not exactly come to the aid of workers in the agricultural sciences, but something akin to it is a most valuable aid to the worker in the biological sciences. Indeed, FREDERIC W. NORDSIEK, '31, shows (page 313) that progress in modern biological sciences would be much impaired without benefit of statistical analysis. Mr. Nordsiek is assistant to the director, Department of Applied Research, Standard Brands, Inc.

Wright Era. — Comments on the quiet, modest life and methodical working habits of Orville Wright, whose recent death closes a bright chapter in American initiative, are given (page 309) by genial FRED C. KELLY, close associate with the Ohio inventors. In Review articles, as well as in the volume *The Wright Brothers*, Mr. Kelly has told the story of two modest inventors.

QUIZ ON HIGH SPEED STEELS



Q. How long have molybdenum high speed steels been used successfully?

A. For about 15 years.

Q. Why are molybdenum high speed steels preferred to 18-4-1 by many large consumers of tool steels?

A. They're tougher. Do a better job for less money. They're from 10¢ to 20¢ a pound cheaper. In addition, the molybdenum steels have from 6% to 9% lower density, so if you make your own tools, you get more tools for a given gross weight.*

Q. Where are users finding molybdenum high speed tool steels superior?

A. In twist drills. In hacksaw blades. In milling, slotting, and slitting saws. In taps, chasers, broaches, reamers, hobs, milling cutters, lathe and planer tools. Can be used for all classes of high speed tools with good results.

Q. Is there any special trick needed in heat treating molybdenum high speed tool steels?

A. No. In modern furnaces, molybdenum high speed tool steels are as easy to harden properly as 18-4-1. *And* they cost much less—and *save money on the job.*

**Our booklet on molybdenum high speed steels will give you proof of these statements. Write for it.*

MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

Climax Molybdenum Company

500 Fifth Avenue · New York City

MOLY

HANDS by Robert Comport, a prize-winning Photo study.

Winning Combination

STARRETT TOOLS

STARRETT TOOLS combine quality, accuracy and fine workmanship—the choice of all skilled craftsmen for precision measuring.

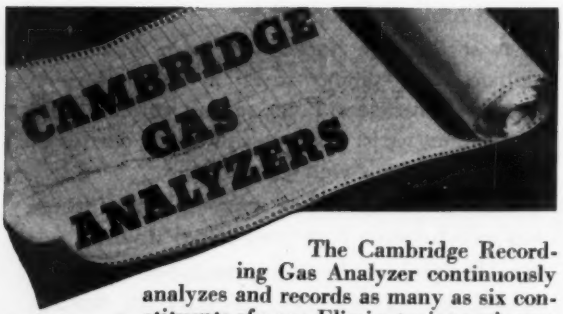
Write for Starrett Catalog No. 26 "L."

STARRETT

PRECISION TOOLS • DIAL INDICATORS
STEEL TAPES • GROUND FLAT STOCK
HACKSAWS • BAND SAWS FOR CUTTING METAL, WOOD, PLASTICS

Buy Through Your Distributor

THE L. S. STARRETT CO. • *World's Greatest Toolmakers* • ATHOL, MASSACHUSETTS, U. S. A.



The Cambridge Recording Gas Analyzer continuously analyzes and records as many as six constituents of a gas. Eliminates intermittent, slow and expensive manual gas analysis. Accurate . . . Sensitive . . . Simple. No moving parts; utilizes thermal conductivity principle.

Makes possible substantial savings in the operation of kilns, production of inert gases, and in metallurgical, petroleum, and other chemical processes. Single- and Multi-point instruments are available for a wide variety of applications.

Send for literature mentioning application

CAMBRIDGE
INSTRUMENT COMPANY, INC.
3707 Grand Central Terminal, New York 17

Pioneer Manufacturers of
PRECISION INSTRUMENTS

MAIL RETURNS

Stacks—Straight and Flaring

FROM EDWIN C. SMITH, '91:

In the picture of the "Last Spike Ceremonies" (page 264), one locomotive is shown with a straight stack and one with the flaring funnel type. In my mind the funnel-shaped stack has been associated with the old "wood burner" while the straight stack was the hallmark of the coal burner. Recently, some inquiries were made but without results. One correspondent, an old railroad man, was sure the above was right but on attempting to support his belief from records was unable to do so. In my almost 80 years of travel and observation, the straight stack has prevailed, but I recall, back in the late 'Seventies seeing one or two of the funnel type which were identified to me as "wood burners." The stack with which I was most familiar was called the "diamond head," according to my recollection. That, like the funnel stack was set practically at the extreme front end of the boiler. Then the body of the boiler was, as recalled, extended to form a cinder trap, replacing the old screen spark arrester.

Now, the above is rather a hodgepodge of old recollections but I am fatuously interested in learning whether the funnel type was characteristic of the wood burner or just a circumstance.

Providence, R. I.

On Our "Cobblestones" Cover

FROM MARSHALL O. LEIGHTON, '96:

Were The Review not so sound a magazine in respect of exactitude of expression, I would not have been startled this morning when I took up my March number.

The cover exhibits a remarkably fine reproduction of good old granite paving blocks, which in my boyhood days were the latest thing in city street paving. We called them Belgian blocks. I gazed at them for some time amid nostalgic sentiments. To my astonishment I observed, when I reached page 255, that the title was "Cobblestones." Cobblestones are natural rounded stones large enough to be used for paving.

Washington 5, D. C.

Well, Then—We Are Young!

FROM WILLIAM C. PICKERSGILL, '00:

The cover of the March issue is a very interesting photograph but as you undoubtedly know these are not cobblestones. Perhaps some are too young to remember what real cobblestones looked and felt like when riding over them on a bicycle. Good old square-cut granite blocks are a luxury compared with a real cobblestone.

This is not a criticism of The Review. I enjoy it very much and wish you all success. It may be just a memory brought to mind by an old photograph of some '99 and '00 boys which I happened to run across a few days ago.

Newton Highlands, Mass.

Speed with Economy

Bilhuber-Knoll Corp.

If your production needs call for a new building, you certainly want it quickly . . . But don't overlook *quality*. Choose a builder with a record for both speed and good workmanship.

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, Vice President

One man—serving all three —saves your time

For more than twenty years Carbide and Carbon Chemicals Corporation has maintained a staff of technically trained representatives to serve its customers throughout the country. Now, more than ever, this policy means time and effort saved for you.

Every Carbide representative is a graduate chemist or chemical engineer. This basic technical knowledge, plus research experience in our laboratories, special training in our home office, and practical knowledge gained in the field, gives our representative the background needed to be of assistance to all three, the men in your plant, your laboratory, and your purchasing department.

When you have problems involving the use, development, or purchase of chemicals, call our nearest office and discuss them with a Carbide representative. And if you would like a copy of our catalog, "Synthetic Organic Chemicals," please address Department "A."

CARBIDE and CARBON CHEMICALS CORPORATION

Unit of Union Carbide and Carbon Corporation

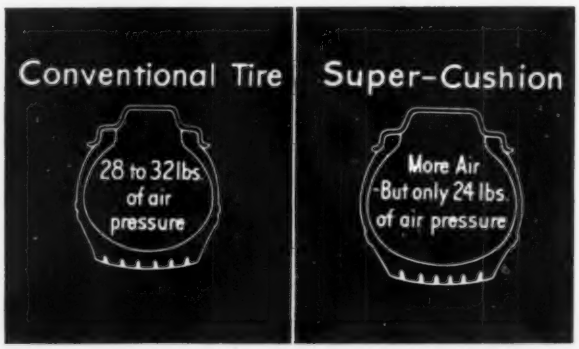
30 East 42nd Street UCC New York 17, N. Y.

Offices in Principal Cities

In Canada:
Carbide and Carbon Chemicals, Limited, Toronto

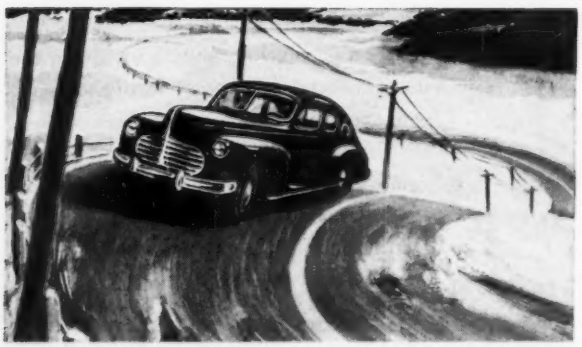
"First new kind of tire in 15 years!" car makers say

AUTO MEN QUICKLY PUT GOODYEAR'S GREAT NEW SUPER-CUSHIONS ON THEIR NEW CARS! HERE'S WHY:



1. Cars ride softer—handle easier and more safely! Super-Cushions are bigger, softer than conventional tires. Run on only 24 lbs. of air pressure. You get an unbelievably smoother, softer ride. Your car handles with an ease and stability you've never known—*hugs* the road, *flows* around turns.

2. Super-Cushion licks lateral shock—slashes car maintenance costs! The Super-Cushion is *first* to lick lateral (crosswise) shock. Pillow-like Super-Cushions *soak up* these crosswise jolts, *soak up* vibration. That means less stress and strain on *you and your car!* Fewer rattles, fewer repair bills!



3. Super-Cushions give greater mileage—have extra resistance to blowouts! Super-Cushions run *cooler*. By keeping heat *down*, they boost wear *up*—averaging *more mileage than the finest standard tires!* Softer Super-Cushions "roll with the punch," are harder to cut or bruise, have *extra* resistance to blowouts.

And *bigger* Super-Cushions "dress up" *any* car!

See your Goodyear dealer now—
and switch to Super-Cushions

The new *Super-Cushion*
by GOODYEAR

Super-Cushion T.M., The Goodyear Tire & Rubber Company

VOL. 50 No. 6

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

☆ ☆ ☆

Contents for April, 1948

LEXINGTON MINUTE MAN • *Drawing by Sidney L. Kaye* . . . . . THE COVER

SPRING PLOWING • *Photograph by H. Armstrong Roberts* . . . . . FRONTISPIECE 308

ORVILLE WRIGHT AT WORK . . . . . BY FRED C. KELLY 309

THE MATHEMATICS OF LIFE . . . . . BY FREDERIC W. NORDSIEK 313
Like his colleagues in the physical sciences, the biologist turns to statistics to evaluate results of his researches

ÉVARISTE GALOIS . . . . . BY DAVID AND CHARLOTTE B. LANDAU 316
A turbulent life in a revolutionary period created a wealth of mathematical riches

AH, SWEET MYSTERY OF SLEEP . . . . . BY M. F. ASHLEY MONTAGU AND EDWARD MILTON 319
". . . the cares, that infest the day, shall fold their tents, like the Arabs, and as silently steal away."

WHAT'S ON THE WORKER'S MIND? . . . . . BY PAUL MEADOWS 322
American workers are divided on many questions, but a common pattern runs through their thinking

THE TABULAR VIEW • *Contributors and Contributions* 302

MAIL RETURNS • *Letters from Review Readers* 304

THE TREND OF AFFAIRS • *News of Science and Engineering* 309

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 325

☆ ☆ ☆

Publisher • H. E. LOBDELL *Editor* • B. DUDLEY *Business Manager* • R. T. JOPE
Editorial Associates: PAUL COHEN • T. L. DAVIS • J. R. KILLIAN, JR. • WILLY LEY • F. W. NORDSIEK
J. J. ROWLANDS • D. O. WOODBURY
Editorial Staff: THEODORA KEITH, RUTH KING *Business Staff:* MADELINE R. MCCORMICK

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Raymond H. Blanchard, President; H. E. Lobdell, Executive Vice-president; C. George Dandrow, John A. Lunn, Vice-presidents; Charles E Locke, Secretary; Ralph T. Jope, Treasurer. Published at the Rumford Press, 10 Ferry Street, Concord, N. H. Editorial Offics' Room 7-203, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the post office at Concord, N. H. Copyright, 1948, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect changes of address, for which both old and new addresses should be given.

H. Armstrong Roberts

Spring Plowing

THE
TECHNOLOGY REVIEW

Vol. 50, No. 6 April, 1948

The Trend of Affairs

Orville Wright at Work

By Fred C. Kelly

ORVILLE WRIGHT'S greatest pleasure, to the end of his life, was in his work. Less interested in benefiting from what he found out than in satisfying intellectual curiosity, he continued to be an inventor. He spent every day, usually including Sunday, at his office and laboratory which have been dismantled since Mr. Wright's death. The place was a one-story building at 15 North Broadway on the west side of Dayton, about four miles from his home and within short walking distance of the site of the Wright bicycle shop, where work on the airplane started. The front of the office building was suggestive of a village bank. There were two rooms in the office part — one a sort of reception room, severely furnished. Back of this room was an immense fireproof vault containing the voluminous Wright archives of scientific work covering a period of nearly 50 years. Across a small hallway was the office workroom. The whole place had a working atmosphere, with nothing about it of coziness or comfort such as a man in retirement might want if he were seeking only a place in which to loaf or put in his time.

Back of the office part of the building, a few steps down, was to be found the laboratory, a fully equipped machine shop, 40 by 60 feet. Here Orville Wright devoted himself to whatever scientific project claimed his interest. It was here that he invented the split-wing flap.

As faster, more powerful, planes were being designed after World War I, there was need of means for slowing them down when making landings. Orville hit on the idea of the split-wing flap, the performance of which he first demonstrated in his small wind tunnel in December, 1920. He was able to prove that by lowering a flap — part of the wing surface hinged along a line several inches forward from, and parallel to, the rear edge — a pilot could increase the wind resistance of the wing and retard the speed of the machine. Through the Dayton Wright Company, Orville offered the invention to the United States Navy in April, 1921, although he did not patent it until May 21 of that year. By July 15, 1921, the Dayton Wright Company was offering a plane, that included the invention, to the United States Army. But neither the Navy nor the Army made any use of it for some time. In its issue of August, 1935, the *Journal of the Royal Aeronautical Society*, in Great Britain, commented editorially: "A patent for a split traveling edge was granted to Orville Wright in 1921, and it would be interesting to know why it was neglected for ten years or so."

Not all Orville Wright's inventions, many of which he has never even bothered to patent, have to do with aviation. Recently, he devoted much time to the perfection of a machine for writing and translating cipher codes.

A person would have been fairly safe in setting his watch by Orville Wright's arrival at his office in the morning, as punctually at 8:30 as if he had to punch a time clock. And he was equally sure to return from lunch, which he nearly always ate at home, at exactly 1:30.

Unseeing Eyes

THE concept of micro-organisms as causes of disease at first seemed so improbable that the germ theory of infection was doubted in some quarters until well into the Twentieth Century. How much greater a challenge to the human imagination, then, was the idea of a submicroscopic parasite that preys upon microscopic bacteria. Such a parasite is bacteriophage, first announced by d'Herelle a quarter of a century ago. In 1925, Sinclair Lewis capitalized on the dramatic nature of bacteriophage by making it the research subject pursued by the hero of his novel *Arrowsmith*. Phage was soon found to be an important element in the balance of nature, as for example in the destruction of bacteria in heavily polluted waters, and phage also developed economic significance when it proved to be the cause of previously unexplained difficulties in certain industrial fermentations.

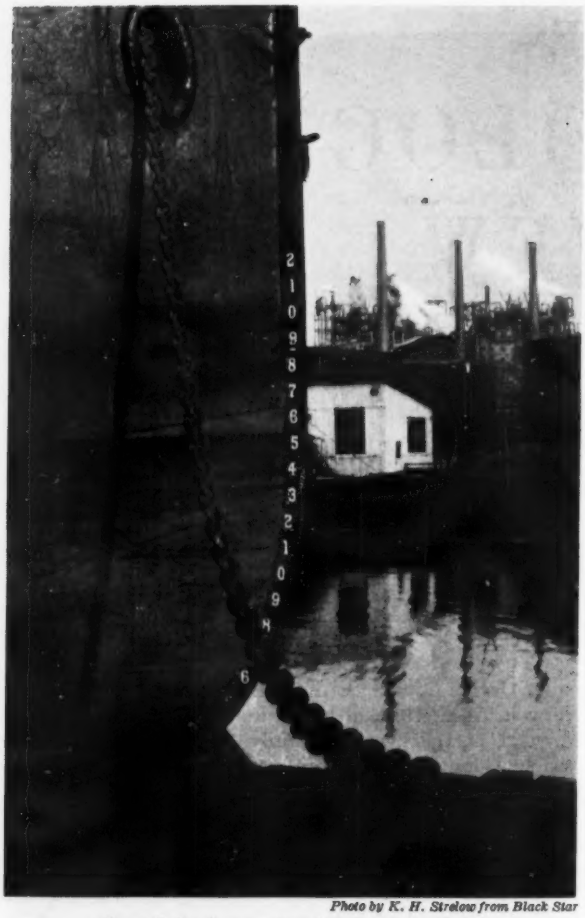


Photo by K. H. Strelow from Black Star

Great Lakes boat anchored in Cuyahoga River

D'Herelle's pioneer work with bacteriophage was soon confirmed by other workers, although this subsequent research was done by studying only effects, without observation of the phage itself. Since bacteria come close to the limit of visibility afforded by the compound microscope, the best optical instrument available at that time, a search for entities still smaller than bacteria seemed pointless. But fortunately biologists are accustomed to studying effects of agents without coming to grips with the agent itself; thus much of the work with vitamins, hormones, and enzymes was, and still is, done in such terms, by working with more or less crude concentrates, but with no conception of the nature of the active substance involved. As the study of bacteriophage progressed, a theory gained some acceptance to the effect that it was enzymic in nature, rather than being an organized entity as postulated by its discoverer.

Then invention of the electron microscope pushed the range of human vision beyond its previous barrier, the wavelength of light. By 1943 bacteria under attack by bacteriophage had been observed extensively under the electron microscope, and were seen to contain particles not present in other bacteria, particles that logically were assumed to be the phage. The electron microscope, however, can be applied only to stationary objects, and therefore when used to study microbes it is limited to observation of dead and fixed preparations. Therefore, the conclusive stage of this research had to await development of the phase microscope, which shows objects as minute as does the electron microscope, but permits observation in the living, active state. Brought to bear upon bacteria affected by phage, the phase microscope revealed that the particles previously seen under the electron microscope pass through an interesting chain of events. They increase in size as they approach the victim, and the bacterium under attack becomes immobilized. The particles then attach themselves to the bacterial cell, briefly diminish in size just after attachment, then increase in size. The bacterium bursts, releasing the flow of its protoplasm, and finally new particles, like the original ones, develop within the liberated protoplasm. These observations showed beyond doubt that the particles are surely bacteriophage, thus giving the quietus to the enzyme theory by establishing the phage to be an organized entity, withal necessarily different from life as we know it.

In the light of these advances, preparations of bacteria infected by bacteriophage were studied intensively under the ordinary compound microscope, which provides magnifications up to some 1500 diameters, but no higher. Special staining techniques were developed to delineate the bacteriophage. With these stains, all of the stages of phage attack just described became clearly visible. Contrary to the long-held belief that they were submicroscopic, it is now clear, therefore, that bacteriophage is clearly visible under ordinary microscopes, provided the observer knows how to look and what to look for.

This discovery stimulated a re-examination of d'Herelle's original publications. Startlingly enough, these papers revealed that he had observed bacteriophage under the ordinary microscope in the early 1920's. Subsequent controversy about the nature of bacteriophage had apparently obscured this pronouncement. Thus, in a by-no-means unprecedented fashion, a well-articulated, early discovery was ignored, and lay fallow until other advances — in this instance, invention of the electron and phase microscopes — had conditioned the scientific mind to its acceptance.

Roll out the Barrel

A CONTAINER widely used today that is still made exactly as it was in ancient Egypt is the wooden barrel. Prime advantage of the barrel is its extraordinary strength; this characteristic inheres in its shape, which is that of a doubly truncated ellipsoid. Since most of the barrel's walls are therefore spheroidal in contour, they possess the great structural strength of the dome or multidirectional arch. Another advantage of the ellipsoidal shape is that the wooden barrel, when lying on its side, the proper position for moving, makes a virtually single-point contact with the floor. It is, therefore, almost as mobile as a sphere, but is easier to guide than a sphere because of its elongated shape.

Any cooper would shudder to hear the reference just made to the "side" of a barrel, for to him this area is known only as the "bilge." Among other esoteric, withal euphonious, terms stemming from the antiquity of the cooper's craft are: croze, chime, howel, hackleback, and cant; meaning, respectively, the groove near the ends of staves into which barrel heads fit, the section of staves between the croze and the end, the portion of the stave

that is grooved to make the croze, an untrimmed stave, and the outside piece of a multiple-piece barrel head.

Wooden barrels are of two broad types, tight and slack. Tight barrels are used for liquids, syrups, oils, greases, and similar substances requiring a fluid-tight container. Slack barrels are not liquid-tight: they are used to hold multifarious materials ranging from fresh fruits to nails and spikes, and when fitted with a sift-proof liner, are used for dry powdered products, such as dry-milk solids or powdered detergents.

Since the various plentifully available domestic woods have a wide array of physical properties, barrels may be made with correspondingly varied characteristics, to adapt them for specific uses. Thus, whisky barrels are made of quarter-sawed white oak, syrup barrels of gum-wood, fish barrels of ash, and so on. Illustrative of the extreme versatility of this container is that wine barrels have the porosity necessary for the "breathing through the wood" considered by vintners to be essential in the maturing of wines, whereas beer barrels are able to hold a carbonated fluid under considerable pressures.

Use of cooperage through the centuries has given rise to complex and sometimes confused systems of units for materials packed in barrels. Today barrels are made in many sizes, but when currently spoken of as a unit of capacity the barrel usually designates some 30 gallons. In general, a hogshead has twice the capacity of a barrel, a pipe, twice the capacity of a hogshead. The tierce, a barrel often used for shortenings and lard, is one-third of a pipe (literally tierce means a third), so that the tierce is intermediate in size between the barrel and the hogshead. Although in recent decades little flour has been packed in barrels, the long-established (and still currently used) unit of flour weight is the barrel of 196 pounds. This odd weight derives from the fact that capacity of the flour barrel was originally set at 14 stone, the stone being an ancient and once variable weight unit, finally standardized by British law at 14 pounds.

To you, "pork barrel" may mean political patronage, but to the cooper the pork barrel is an important and rigidly defined item of his wares, made of 9/16th-inch oak or ash, planed inside and out, with heads having not more than six pieces and no cant under three inches in width, supplied for packing salt pork and similar cured meats.

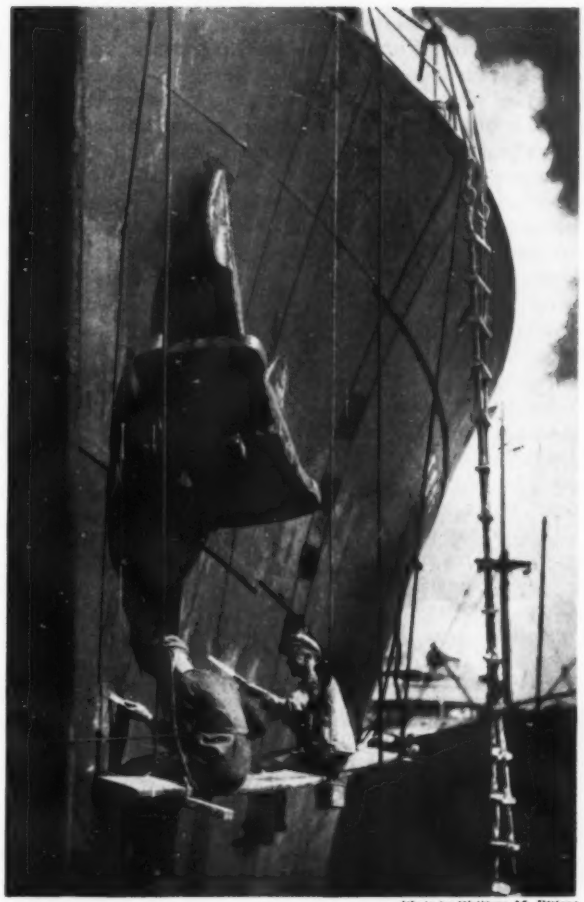


Photo by William M. Rittase

In dock for cleanup and repairs

Mysterious Work Horse

MOST hard-working and most versatile among the many industrially important enzymes is invertase. Enzymes are biological agents that act like catalysts, to bring about changes or reactions without being changed or used up themselves. Enzymes are valuable in industry because they often can produce effects at neutrality and at moderate temperatures, effects that could be produced by chemical means only with extreme acidity or alkalinity and high temperatures. Furthermore, the specificity of enzymes is useful, since in general they attack only their particular substrates. Thus, an enzyme mixture widely used for desizing textiles vigorously breaks down both proteins and starches in the sizing, but does not in the least affect the textile fibers, whereas any chemical that could accomplish the same purpose would also attack the fibers.

Invertase is versatile in its applications, not in its functions, because it does just one thing: it divides the molecule of sucrose (common cane or beet sugar), adds a molecule of water, and thereby produces one molecule each of the simple sugars dextrose and levulose, a mixture known as invert sugar. This change, called inversion, is part of the metabolism of many different types of living things, as demonstrated by the widespread occurrence of invertase in nature. In the human being invertase is found in the intestinal digestive juices, where it serves to invert any sucrose in the dietary not previously inverted by the acidity of the stomach juice. Sucrose must be inverted as the first step in its assimilation, since it cannot be absorbed, whereas both dextrose and levulose can. Invertase also occurs in molds, in bacteria, in the stems, leaves, blossoms, and fruits of higher plants, in the blood and eggs of invertebrates, in primitive animals, such as jellyfish, in the saliva and intestines of honeybees, and in the tissues or body fluids of birds and of higher animals other than man. By far the richest natural source of invertase, however, is yeast.

Technological uses of invertase include laboratory applications for preparation and isolation of certain sugars, and as a reagent in the quantitative assay of sugars. Invertase also is involved in all industrial fermentations where alcohol is produced from substrates containing sucrose, as invert sugar is fermentable, whereas sucrose is not. This means that invertase enters into the production of alcoholic beverages, as well as of industrial alcohol.

An important but often unrecognized ramification of this latter function of invertase is the inversion of sucrose in yeast-leavened doughs for the making of baked foods. Invertase plays a role in the malting industry. It also is valuable in the production of invert sugar for use as such, in applications where the ordinarily cheaper method of inversion by acid and heat is not practical. In certain concentrations invert sugar is considerably sweeter than the sucrose from which it is derived, so that where sugars are used for the sake of sweetness, inversion may be economical. Furthermore invert sugar is more soluble than sucrose; thus invertase may be used in confectionery centers prepared from sucrose that are hard and firm when first made and thus can easily be handled for operations, such as chocolate coating, but later develop a desirable softness by invertase action and because of the greater solubility of invert sugar. The paper industry can also make use of invertase because invert sugar is a commonly employed plasticizing agent. The levulose half of invert sugar is the one with plasticizing properties.

Despite the wide use of invertase, its nature remains a mystery. This of course is equally true of all the other enzymes. Some 200 enzymes have been identified by their effects, but only eight of them have been isolated in crystalline form, and even of these eight the chemical nature has not been established conclusively. Thus a recently published monograph about invertase examines over 400 references on the subject, but is unable to extract from these a definite answer as to either the nature or mode of action of invertase. But despite its aura of mystery invertase remains a most productive industrial work horse.

Flying Salesman

FOLLOWING a war, there have been marked advances in techniques of salesmanship stimulated either by war-developed techniques or the pressures of competition. After the Civil War, for example, the development of the railway created the national salesman known as the drummer. The post-Spanish-American War period saw the introduction of the quota system, the telephone, and the standardized sales argument. After World War I, marketing research techniques using the Hollerith punched card were introduced, and the automobile became an important vehicle for salesmen.

Now, following World War II the airplane has rapidly risen to prominence in selling. Perhaps the chief patrons of commercial air lines are business executives and salesmen. But in addition the airplane has become as familiar to sales staffs as Pullman cars or automobiles of prewar days.

The flying age in selling is here in a new and startling fashion. The salesman who drives his own plane and even calls on customers by landing on company airfields alongside the factory is no longer a rarity. Entire corps of salesmen operate their own planes, and sales executives often own their own planes in which they visit branch offices. And of course executives who visit branch plants, call on principal customers, or drop down to Washington to see a government official are no longer to be numbered merely by the dozen but by the hundred. When it is realized that an hour of an executive's time may be worth $100 to $500, it is easy to see that there is a real opportunity for the company plane or planes, with a company pilot and a systematic, planned use of their modern time annihilator to speed up selling operations.

Nor is this all. Demonstration planes, equipped with the firm's products on display, can speed around the country, or even out of the United States, as some companies are now doing. District sales meetings, operated by a crew which travels via such planes, or traveling displays open to customers, who are delighted with the novelty of visiting an exhibit on a plane, are among the interesting possibilities. But the unexpected possibilities, such as high-speed delivery of a heavy machine or special part, for example, make a favorable impression on customers and outspeed a competitor. The flying salesman is a fixture already in our technology and has quietly and characteristically become a part of our daily lives.

Pritchett Hall, on the second floor of Walker Memorial, has recently been completely remodeled and redecorated as a student lounge and milk bar. Conveniently available to all Institute buildings and activities, the new lounge provides a congenial recreational center where students may entertain their guests or enjoy refreshments during the evening. The serving counter is at the extreme right in this picture, although all but the entrance is removed from view by the vertically striped screen.

The Mathematics of Life

Denied the Physical Scientist's Methods of Simplification, the Biologist Makes Increasing Use of Statistics in Analyzing the Results of His Research

By Frederic W. Nordsiek

NOT long ago biology was a purely qualitative science, preoccupied with such activities as nomenclature, classification, morphology, and anatomy. Consequently, as late as the 1930's, students of biology received comparatively little training in mathematical analysis. But today the situation has changed and, at M.I.T., they receive as much mathematics as any other course of study at the Institute. Significantly, at M.I.T., the name of the biology course has been changed to Quantitative Biology. These observations reflect the extent to which mathematics (especially statistics, called the mathematics of experimentation) has now become an essential tool of the biologist.

Statistical procedures must be used to interpret quantitative biological experiments chiefly because of the present relatively primitive state of biological knowledge, and the need to draw significant conclusions from experiments on few samples. The physical sciences are easier to deal with and hence are more advanced; there a known combination of causes usually leads to a fixed and predictable result. Thus the physicist may readily set up a coil having a radius of two centimeters ($r = 2$) and four turns ($N = 4$). He can pass through this coil a current of precisely five amperes ($I = 5$); and he knows that if he does so a magnetic field, H, of 6.28 oerstedf will result in the core of the solenoid, since $H = 2\pi NI/10r$. Similarly, the chemist can weigh out 40.01 grams of sodium hydroxide and 36.47 grams of hydrochloric acid, both of established purity; and he can foretell with assurance that if such quantities of these two compounds are mixed, they will neutralize each other and will produce 58.45 grams of sodium chloride and 18.02 grams of water ($NaOH + HCl \rightarrow NaCl + H_2O$).

In sharp contrast, the biologist rarely can equalize or otherwise precisely control his experimental elements at the beginning of a study. Suppose he wishes to learn the effect of a certain food upon the growth rate of albino rats or on the English setters shown in the illustrations. Can he hope to start with two or more animals of exactly the same weight? Very rarely is he able to do so, because even among animals born of the same parents and in the same litter, marked differences in weight usually exist at birth, and these differences widen as the animals mature. This disparity is true despite use of highly standardized strains of animals that have been bred for decades specifically for laboratory use.

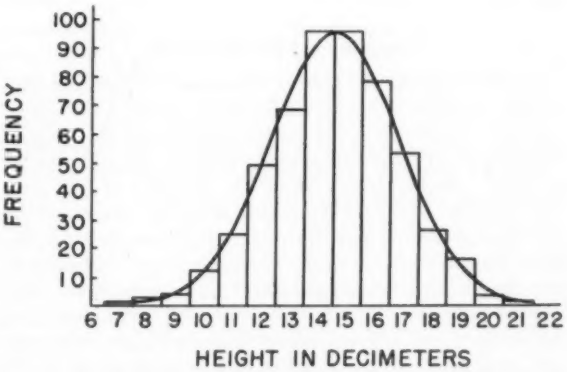
Granted, then, that the biologist seldom can establish his initial experimental framework with precision, to what extent can he control his variables in the course of a study? Referring again to a simple feeding experiment, can precisely fixed amounts of ration always be fed? Again the answer is no, because if animals are allowed to eat freely, they are apt to consume differing quantities. Precisely weighed amounts of food can be given by forced feeding, but this procedure is abnormal and may distort results because of injury or distress to the animals.

Extending the illustration afforded by an elementary feeding study, let us finally consider the happy but rare situation where two litter-mate animals are found that have the same initial weight and consume the same amount of food at the same rate. Even under such conditions of virtually unattainable perfection, the animals probably would not weigh the same at the conclusion of the experiment. In short, presumably equalized conditions in biological research are apt to lead to unequal results.

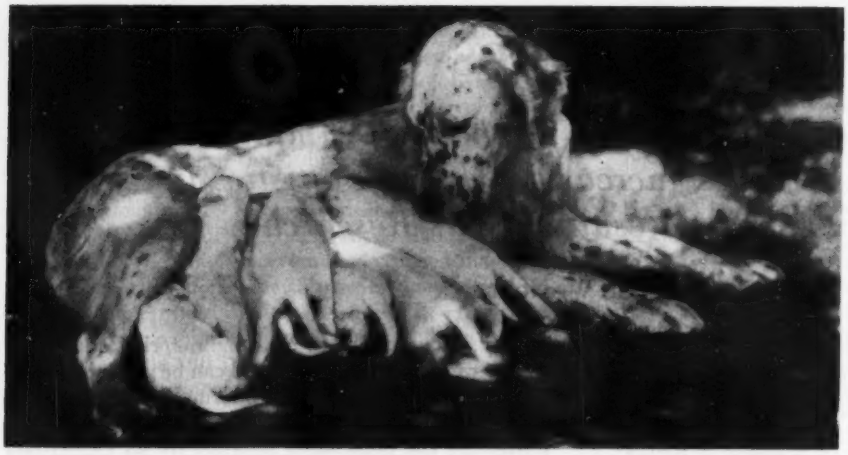
Obstacles to Quantitation in Biology

The relatively uncomplicated experiment just cited demonstrates three obstacles faced by the biologist in quantitative research. Seldom can he equalize the experimental and control elements at the outset of a study. Rarely can he adjust his experimental variables with precision. Finally, even if by sheer good fortune these two factors are held constant, the outcome still probably will be variable.

Whence these obstacles to quantitation in biology? They stem from the fact that significant biological research must be done with whole living organisms, because *in vitro* experiments at best yield limited information. Therefore, unlike the physicist or chemist, the biologist



The rectangles represent the relative frequency with which corn plants grow to the heights indicated on the abscissa, according to a study of 530 plants of the same variety and age and grown on the same plot of land (Emerson, R. A., and East, E. M., Nebraska Export Station Research Bulletin 2, 1913). *The smooth curve is the normal distribution curve which might be expected to result when a very large (theoretically, infinite) number of plants are examined. The normal distribution curve plays an important role in biological studies; in a sense it is the basis of "the mathematics of life."*



Unlike the physicist or chemist, the biologist cannot segregate his problem into elementary independent and isolated components for subsequent integration into a complex system based on the principle of linear superposition. Instead, he must deal immediately with a complex system, which is the living plant or animal. If he wishes to study the effect of certain food on the growth of animals, he will be fortunate if he can find a group of animals of the same weight and size and belonging to the same litter.

Photo by Harold M. Lambert

cannot segregate his problems into elementary components like electromagnets or acid-base reactions, for subsequent integration into complex systems. Instead he must deal immediately with a complex system, which is the living plant or animal. But today only the most superficial aspects of the functionings of living things are understood. As a result the biologist encounters in every organism many variables which he does not know, and hence cannot control. Such unknowns may outweigh the factors that he understands and is able to vary experimentally at will.

Yet a point has long since been reached where biological sciences essential to human welfare can advance only to the extent that their findings are expressed quantitatively. Thus the pharmacologist must establish dosages, the nutritionist needs to measure nutrient requirements in units as exact as milligrams, the immunologist must standardize serums and antitoxins derived from living animals. Fortunately statistics, an application of mathematics, "queen of the sciences," makes possible such quantitation on the basis of concepts we shall describe, and by means of procedures typified by one we shall demonstrate presently.

The Normal Distribution

A fundamental principle of biological statistics is that certain qualities of samples selected at random do not all have the same value but vary according to the normal distribution. This relationship is illustrated by the graph in which the rectangles show the heights of 530 corn plants of the same variety and the same age, grown on the same plot. Observe first that, as would be expected in the light of our discussion so far, these plants are not alike in size, despite their common nature and environment. The heights range all the way from 7 to 21 decimeters; but extremely short and extremely tall plants are relatively few, and most of the heights fall at or near 14 or 15 decimeters. The curve that has been sketched in on the graph is called the curve of normal distribution; it is the curve which would result if an infinite number of objects — corn plants in this case — were examined.

The normal distribution is ubiquitous in nature as it is in other situations in which variations result from unassignable causes. It may be observed in weights of animals, numbers of ridges on the shells of crustaceans, numbers of colonies on agar plate cultures of bacteria, even in the volumes of loaves of bread, for bread loaves are truly biological phenomena, since they are leavened by a living organism, yeast.

Then, too, the normal distribution appears in broad terms in everyday experience and observation. Thus people of middle stature are often seen, whereas extremely short or extremely tall people are relatively rare. A single normal distribution is not, however, reflected here, because the heterogeneous population we see from day to day includes various racial stocks, each having its own characteristic height distribution. Moreover, the height distribution of women is essentially the same as that of men, although the mean height of women is, of course, smaller than that for men.

Chance in Statistics

Why do quantitative characteristics of living things usually follow the normal distribution? Although the full answer to this question cannot be given here, a most illuminating insight may be gained by consideration of the fact that similar distributions also appear in certain nonbiological phenomena, such as results of the tossing of coins. If a handful of coins is tossed together repeatedly a sufficiently large number of times, the outcome according to division between heads and tails will show much the same picture as do heights of corn plants (page 313). Tosses showing all heads or all tails will be as rare as the 7 or 21 decimeter heights. Roughly equal numbers of heads and tails will be as common as the 14 and 15 decimeter heights, and intermediate assortments of heads and tails will slope off symmetrically like the intermediate corn heights.

Coin tossing is usually thought of as governed by chance. Nevertheless all of the influences that determine the outcome of tosses are actually ponderables, such as position of coins in the hand, cleanliness and degree of wear of coins, force applied in tossing, angle of incidence of this force, height from the floor at which the toss is made, levelness of the floor, and resiliency of the floor covering. Therefore, "chance" in this sense is actually the combined effect of numerous variables that are neither regulated nor measured. Does not this last phrase have a familiar ring? Earlier in this article it was said, "the biologist encounters in every organism many

Should the biologist be fortunate enough to be able to carry on experiments (such as those to determine the effect of certain foods) with animals essentially identical at birth, wide differences in the weights of animals may be expected as the animals mature. Thus, the biologist is rarely able to equalize or otherwise precisely control his experimental elements during study, and hence he must resort to indirect means of evaluating his observations. In the evaluation of his studies, statistics play a major role.

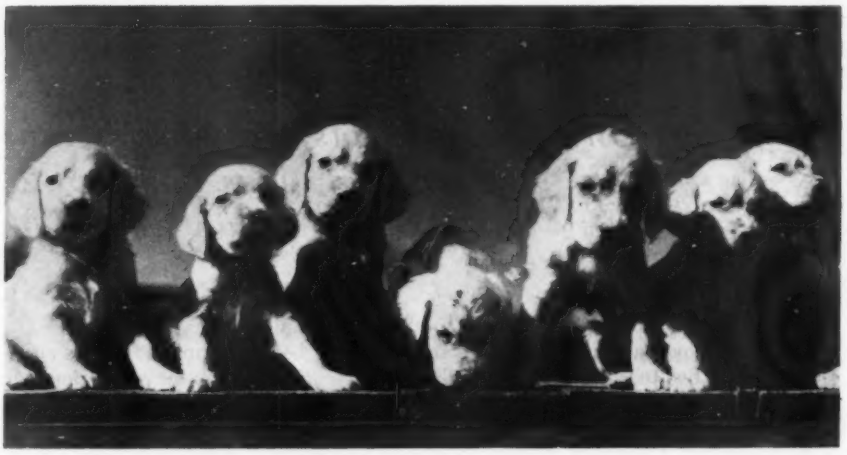


Photo by Harold M. Lambert

variables which he does not know, and hence cannot control." The parallelism here is obvious. In fact the word "chance" is retained in statistical terminology to designate this relationship.

Overlapping Normal Curves

Let us then accept as axiomatic that, in general, biological phenomena when suitably segregated (such as separation of sexes in the height distribution of human beings) follow the normal distribution. To understand how this concept helps in interpreting quantitative studies of living things, suppose that the corn plants whose heights are shown in the graph are controls in an experiment, and that an identical group has been grown under the same conditions except for addition to the soil of a fertilizer that has the effect of increasing height. The observed heights of the fertilized plants could then be arranged in an array like the graph. These results would also follow a curve of normal distribution, but one lying further to the right, in the region of greater heights. If both control and experimental groups thus include as many as 500 individuals, significance of results is easy to measure. For example, if the two distributions had identical conformations, and the peak and extremes for the fertilized corn lay two decimeters higher than those for the control plants, the conclusion would be plain not only that the fertilizer had the effect of increasing heights, but also that it did so to the extent of some two decimeters.

Note, however, that since the control plants range from 7 to 21 decimeters in height, and the fertilized plants from 9 to 23 decimeters, most of both groups lie in the common range, 9 to 21 decimeters. Furthermore, quite a few of the fertilized plants are actually shorter than quite a few of the control plants. What then of experiments where many less than 500 individuals are observed, as usually must be true in biological studies? With experimental groups too small to fulfill a smooth normal curve, the few observations made are drawn at random from the true normal distribution. Therefore a study of corn heights attempted with only a few plants might conceivably show all of the fertilized plants shorter than all of the unfertilized plants.

In experiments where only limited numbers of animals or plants may be studied, statistical interpretation is indispensable. Procedures for this purpose are based on mathematical handling of the relationship expressed graphically by the curve of normal distribution as shown in the graph. Derivations cannot be given in a discussion of this scope, but may be found in books on the subject, a few of which are listed at the end of this article.

A Small Sample Experiment

Typical of research where only small numbers of individuals usually may be observed are studies of animals. To illustrate this type of experiment a hypothetical study of lambs has been outlined, where two experimental variables are tested against a control. Such research performed on the scale of the survey of corn height (page 313) would require three groups of at least 500 animals each, or a total of more than 1500 animals. An experiment of this magnitude would be prohibitive in cost because of the economic value of the animals, the expense of feeding, the necessary housing, and the time required for observations. As a matter of fact, studies of this type based on 15 animals have been considered ambitious and definitive.

The table shows the data of such an experiment. Although the data and the conclusions they lead to are purely hypothetical, the values have been chosen to show typical weights of lambs. The control group is fed a ration free of vitamin D, and is shielded from sunlight. One experimental group receives (*Continued on page 328*)

HYPOTHETICAL EXPERIMENT TO DETERMINE EFFECTS OF SUNSHINE AND OF VITAMIN D ON WEIGHT GAINED BY LAMBS BETWEEN SIX AND TWELVE MONTHS OF AGE

	Control Group		*Sunshine Group*		*Vitamin D Group*	
Sunshine?	No		Yes		No	
Vitamin D?	No		No		Yes	
Age, months	6	12	6	12	6	12
Animal	Weight of animal (kg.)					
1	27.7	37.1	26.3	41.0	29.6	42.1
2	26.0	39.2	26.6	36.3	27.7	42.5
3	26.7	38.7	28.1	39.1	26.1	40.6
4	29.5	38.0	26.8	42.3	26.8	41.8
5	28.6	39.5	29.6	41.0	28.6	43.0
Mean Weight	27.7	38.5	27.5	39.9	27.8	42.0
Mean Gain	——	10.8	——	12.4	——	14.2
Average "sunshine" gain		12.4 kg.	Average "vitamin D" gain			14.2 kg.
Average control gain		10.8	Average control gain			10.8
Difference		1.6 kg.	Difference			3.4 kg.
p value of difference		0.24	*p* value of difference			0.006

Évariste Galois

Brief Manuscripts of French Genius, whose Life Was Ended at 20 Years of Age, Contain Vast Mathematical Riches

By David and Charlotte B. Landau

MORE than a century ago Évariste Galois bequeathed to the world an enduring monument — the refined gold of a man's mind. The labors of his entire life are so concentrated that they are contained in 60 pages but these few pages are among the most extraordinary ever written by any mathematician. Was there any other genius who left so little which contains so much?

Those who understand Galois remain aghast at the vastness and depth of the foundations built by his remarkable mind. Here was a Titan's brain crowning a boy's body, for Évariste Galois died before attaining his twenty-first birthday. What a loss to France and to mathematical science! What a tragedy human jealousy, ignorance, and stupidity made of a life which could easily have become one of the most productive in the forefront of Nineteenth-Century mathematics. Genius always pays a toll for its existence and there was no exception to this rule even in enlightened, humane, and scholarly France.

The name of Évariste Galois is not too well known today even in his native France. Certainly Galois is not as well known as Descartes, Pascal, Fermat, Euler, or Lagrange — to whose company he had the undeniable right to belong. Napoleon made Lagrange a senator, a count, and a grand officer of the Legion of Honor. The King of Sardinia and Frederick the Great showered honors upon this same savant. How different was the short life of Galois! Because of his youth, his political opinions (which we should today call leftist), and an abundance of misfortunes and misunderstandings, the tragic life of Galois was "unhonored, unwept, and unsung."

The upheavals going on in Europe during the hectic period following the Napoleonic Wars left few spots that were able to retain their earlier tranquility. One of these was the little town of Bourg-la-Reine, situated a mere rainbow stretch from Paris. Although its name had been changed during the Revolution to Bourg Égalité, the town remained a peaceful and calm oasis of the times. It was here that Évariste Galois was born 137 years ago, on October 26, 1811. The house of his birthplace had been built before the French Revolution and was owned by Évariste's grandfather who used it as a private school for boys. At the beginning of the Empire, the elder Galois left his school to his son, Nicolas Gabriel, the father of our subject. The school prospered, not alone because of the disappearance of other scholastic institutions which were in the hands of the clergy but also because of the liberal views held by the Galois family.

In 1811, Nicolas Galois was a friendly and able man of 36. He was a writer of light poetry, an amateur actor, and was deeply entrenched in philosophy. With joy he witnessed the fall of royalty and even the decline of the Empire. He was chief of the town's political party, and also mayor of Bourg-la-Reine.

Opposite the Galois family lived the reasonably well-to-do Demante family who preserved the traditions of intellectual culture. Thomas Demante was a doctor of laws at the University of Paris, and his daughter, Adélaide Marie Demante, married Nicolas Galois and became the mother of Évariste. She was the boy's teacher until he reached the age of 12 — and an able teacher she was. In 1821 a semischolarship was awarded Évariste Galois at the College of Reims, but this was ignored because his mother wished him to remain near her. Évariste entered the Lycée Louis-le-Grand in Paris, in 1823.

What a change it was for the boy to enter that institution, its barred and grilled windows giving it more the appearance of a prison than a school. This contrast was particularly noticeable since he came from a home where everyone smiled even when serious. In the school, on the other hand, everything was in revolt, including the instructors. So reactionary were the school's teachers that they had to be held in check by a director who ruled with an iron hand. The school was a place of horror for young Évariste whose first year at the Lycée began to have its effects on his freedom of spirit. Mathematics did not then have an independent existence as was true at a later date; only a small part of the time was spent on this subject. The pupils were recruited from those in the higher classes of letters, and, strange to say, according to their political views of the future. Galois was able to enter the first year in preparatory mathematics.

By good fortune a copy of Legendre's *Eléments de Géométrie* came into his possession. This book fanned the fire of his mathematical enthusiasm by its crystal-clear lucidity. He was fascinated by its irrefutable logic and read it with understanding, in spite of progressing with the speed of one who reads a story of adventure. In fact, it is stated that he mastered the work in a short while, whereas almost two years would be required for the average student to really absorb its contents thoroughly. His intelligence enabled him to dispense with all effort; like a bird he left the earth to rise to the highest peaks with a mere flap of his intellectual wings.

He next attempted to study algebra, but was unable to find as gifted an expositor as he did in geometry. At first he was discouraged with the subject, but it was not long before he found stimulation in the work of Lagrange who was perhaps the greatest mathematical master of the age. It was in the classic works of this great mathematician that he grounded his algebraic studies. He drank at the source itself, studying Lagrange's *Résolution des Equations Numériques*, *Théorie des Fonctions Analytiques*, and *Leçons sur le Calcul des Fonctions*. What good fortune

that he did discover this teacher, and a little later, another brilliant star in the mathematical firmament — Abel. Galois now began to read with insatiable avidity mathematical works which taxed even the most able mathematician, although he was but a mere lad of 14!

Paradoxical as it may seem, his class work in school mathematics was only mediocre. Undoubtedly this was because his genius could not concern itself with mere plodding through the elementary steps of the traditional school mathematics. Since he solved the most intricate mathematical solutions entirely in his head, how could it have been otherwise? As one might expect, he was far ahead of his teachers. Orthodox details upset him and at times he lost his temper; under the circumstances who would not? Notwithstanding, he carried off prizes in the general examinations.

Courtesy of Scripta Mathematica

ÉVARISTE GALOIS

The disappointments of a turbulent life did not prevent him from making outstanding contributions to mathematics.

In his mathematical work, he was so far advanced that his teachers, including his mother, said that there was something strange about him. Of course a genius is always strange because he has abilities which surpass the standard rules of measurement. There was no yardstick with which to measure the Galois mind. He lighted his own path with a divine light — the halo of genius.

Since mathematics completely dominated this youngster, naturally he found it useless to spend time on rhetoric. He did not want words for he needed only the symbols of mathematical logic. Shall he be blamed for this? Is not mathematics the key, the *passe-partout*, which opened the doors of man's deepest discoveries in all the sciences?

At 16 Galois was already on the road of great mathematical discoveries. He now took the examination to enter the École Polytechnique which then, as today, was the foremost school of French mathematicians. He failed to pass the examination, not because of his own inability, but because of stupid, or perhaps intentional injustice. In commenting on this failure a quarter of a century later, Terquem had this to say about the verdict of the examining board: "A candidate of superior intelligence is lost with an examiner of inferior intelligence." We may imagine how his failure embittered Galois. What boy of 16 would not have been wounded by such a failure to enter the school which he adored so much? Even genius is human.

A year later, at the age of 17, Galois found himself in the company of an able and sympathetic teacher, Louis Paul Emile Richard, who taught advanced mathematics at the Lycée Louis-le-Grand. Richard inspired many great mathematicians, included among whom were the astronomer, Leverrier, the able mathematician, Serret, whose advanced algebra gave the first exposition of Galois' theory of equations, Galois himself, and later the master analyst, Hermite.

Richard surely knew mathematicians. What Richard thought of Galois may be gained from his recommendation that Galois be considered entirely apart from the other students in the École Polytechnique. "Galois was far ahead of any of the pupils. . . . He only works in the highest portions of mathematics," said Richard who would give him the first prize. At the general competition Galois was awarded the fourth prize for a composition which was no different from that of Bravais who took the first. Richard referred to Galois as "the Abel of France." Do we need more than those four words for an eulogy?

In 1829 Galois published his first memoir entitled "*Démonstration d'un Théorème sur les Fractions Continues Périodiques*" in the *Annales de Gergonne*. It is strange that this paper on continued fractions contained no hint on the other important work he had done. During this year he also made his first communication to the Académie des Sciences. He was but 17 years of age when he made, as Auguste Chevalier said, "*des découvertes de la plus haute importance sur la théorie des équations*" . . . and yet he failed to be passed in his entrance examination to the École Polytechnique. The reason is a mystery. Galois now became deeply engaged in expanding these theories — the sequences of which are not exhausted after more than a century! We who have profited from his work certainly owe Galois a debt of gratitude. And yet how little has been done, even in France, to memorialize the name of this young mathematical genius. How many will recall his memory on his next birthday? *

* To commemorate the 100th anniversary of the death of Galois and to keep alive the name, a Galois Institute of Mathematics was founded in 1932. This *beau geste* (and the volume *Galois and the Theory of Groups*) we owe to Professor Lillian R. Lieber, Head of the Department of Mathematics and Director of the Galois Institute of Mathematics of Long Island University, and her husband, Professor Hugh Gray Lieber, Head of the Department of Fine Arts at Long Island University.

Galois did not publish his fundamental discoveries as he wished to present them as a memoir to the Académie. Therefore, as was the custom, he gave the memoir to Cauchy who was, at this time, the leading French mathematician. Cauchy promised to present the memoir to the Académie but he never did. He said he forgot! The failure would have been of small importance had not Cauchy lost the author's manuscript! Had he been asked to do so, Galois would have sent another memoir to replace the one lost by Cauchy. Galois never heard any more from the master mathematician for as Chevalier tells us, the Académie was not interested. This was the beginning of a series of disasters which soured Galois into a contempt of the Académie and academicians. Added to the bitter disappointment which he suffered in the loss of this memoir, Galois received a shock in the death of his father by suicide.

Notwithstanding his genius, the youthful Galois was unable to harvest the field of his fruitful discoveries, being frequently dulled by petty tasks which made him revolt against the teachings and punishments meted out to him. He had a persistent obstinacy, so that nothing daunted him from rising against all odds to the peak of the pyramid of mathematical thought. As a matter of fact, he was already at the top but his teachers did not know it. How could they, these men who knew less than their pupil? In fact, his teachers were often jealous of his gifts. But this was not altogether surprising for the merits of a genius are not understood except by those who are by nature gifted to be almost such themselves. The saying "Genius speaks only to genius" was never more true.

Obsessed by the insatiable love for his subject, Galois presented himself for a second time at the entrance examination of the École Polytechnique; he was now 18. Once more misfortune shook his hand, and he failed. During the oral part of the examination, when his examiner was both wrong and obstinate, Galois became so enraged that, in a sudden loss of temper, he threw a sponge at his tormentor's face. The doors of the Polytechnique were now closed forever to him. Was this new failure due to lack of knowledge of the subject? Hardly. Was it the result of jealousy, ignorance, or stupidity on the part of examiners who were not worthy to sit in judgment? Probably each of these made their contribution, while added to this was the tragic death of Galois' father caused by the intrigues of the clergy. What a cross of ill luck he already carried on his youthful back.

Having decided to become a teacher, Galois entered the École Normale where he remained for two semesters at the end of which he was asked to leave. The new school director leaned in the direction of the royalists and the clergy, and these leanings were not calculated to help our revolutionary mathematician. Because of these inclinations of the school head there were delays and temporizings which had their tragic influences on the spirit of Galois.

Ill luck followed Galois in all his undertakings, even in his one and only love affair. His mathematics alone kept the fire of his reason burning. To this amour, which never abandoned him, he returned when all the rest was dark and dismal.

He now reached the age of 19 and was admitted to university standing. Three papers containing some of his great work with new ground on The Theory of Algebraic Equations were now prepared. He presented these papers to the Academy of Sciences in competition for the great prize in mathematics. These theses were worthy of the prize since they were, beyond doubt, the efforts of an extraordinary mind of extreme originality. With perfect justice Galois said of this work: "I have carried out researches which will halt many savants in theirs." He was right, as his own countryman, Camille Jordan, showed when he "discovered" Galois 38 years after his death and wrote a substantial volume as commentary on "what Galois, at nineteen, had set down on a few sheets of foolscap!"† But now another calamity befell him.

The secretary of the Academy, the famous mathematician, Fourier, received the manuscript and took it home for examination. Before Fourier had time to study its contents death overtook him! A search failed to disclose even a trace of the Galois papers which would probably have yielded a priceless addition to our mathematical treasures. After Cauchy's lapses, what a blow this was to that boy of 19 summers! So hurt was he by this new misfortune that Galois is credited with having said: "Genius is condemned by a malicious social organization to an eternal denial of justice in favor of fawning mediocrity." Who, in his place, would not have felt as much? Successive misfortunes caused his hatreds to grow and, as a consequence, he threw himself into the political circus on the side of the forbidden *Républicains*, who were what we would now call Liberals. Championing the rights of the masses, the revolution of 1830 caused him many troubles, in spite of having at first filled him with joy. For his outspoken opinions he was expelled from the school. Then, as now, politics was a dangerous business in which to mix and Galois dared it *quand même*. France's sonorous notes of freedom — Liberté, Égalité, Fraternité — had not yet been carved into the stones of its public buildings and monuments. Let us divert here for a moment from our main topic and take a look at the conditions under which Galois lived.

Galois had the misfortune to live in one of the most troubled periods of his country's existence. He saw the end of the Napoleonic regime and the invasion of his native land by allies who brought the Bourbons back to France. Under the allies protection, Louis XVIII became King of France and he lost no time in taking away from the people the benefits gained from the Revolution and the Empire. The south of France lived under continual uprisings and the Chambre voted the suspension of individual liberties and instituted violent controls. These became so violent that on the advice of his Minister Decazes, who was a rather liberal-minded person, the King himself dissolved the Chambre, whose members were said to be more royalist than the King himself! This did not prevent new and more reactionary measures to be taken after Decazes was no more in office in 1820. These violent measures caused many conspiracies to rise.

In 1824, Charles X succeeded his brother but he had learned nothing from the events which he had witnessed. His decrees against the liberties of the press and the people caused an uprising against him. He escaped the horrors of the 1830 revolution, however.

Louis Philippe, who, strange as it may seem, was once a professor of mathematics at the College of Reichenau in Germany, returned to France after the fall of the Empire. (*Continued on page 334*)

† *Scripta Mathematica*, VI: 2, June, 1939, page 100.

Ah, Sweet Mystery of Sleep

Differences in Temperament and Metabolism Account for the Wide Variations in Individual Needs for Sleep

By M. F. Ashley Montagu and Edward Milton

THE lecturer looked up from the title page of his notes and out into the politely expectant faces of his audience. "Is anyone here familiar with the socio-economic patterns of the Watusi?" There was no reply other than a change of expression from that of simulated intelligence to one of collective opacity. "Fine," he thought, "now I can really let myself go."

The lecturer's relief upon realization that he was addressing an uncritical audience is most understandable — particularly by those who have ever been tempted to make any public utterance on the nature of sleep. Many have been tempted, for sleep is a common phenomenon in which we all participate to a greater or lesser degree. From a purely subjective point of view, then, we might easily presume that one man's opinion in the matter is worthy of as much consideration as the next. This attitude may account in part for the large body of pertinent and sometimes pungent literature that has accumulated since the time of Aristotle. But in view of the numerous controlled investigations into the nature and cause of sleep that have been conducted by men of scientific training within the last century, it is a foolish amateur indeed who doesn't tread much more gingerly in those same fields where once he was accustomed to prance without restraint. This does not mean that there is no place left for intuition or imagination. There will continue to be room for such expression until all of the physiological and psychological processes involved in sleep are clearly and finally understood.

How far we are from a clear understanding of those processes can be better appreciated when we consider a few of the theories of the cause of sleep that still enjoy some popularity.

Certain investigators believe that sleep is caused by a change in the distribution of blood to the brain. Among this group there is a distinct division of opinion: some hold that an excess of blood in the brain is the determining factor — others state with equal conviction that sleep is induced by a deficiency in the blood supply to the brain. Recent investigators have reported that they were unable to detect any difference in the blood flow to the head in sleep and in wakefulness.

Another theory suggests that sleep is caused by the presence of toxins or waste products in the blood stream which exert a depressing effect upon nervous tissue. Still another theory depends upon the belief that a gap between nerve cell endings along a nerve fiber develops to an extent sufficient to break contact between the neighboring nerve cells. The resulting cessation in the conduction of those normal impulses that ordinarily flow along the nerves from the various sense organs to the brain during the conscious state leads, so the theory goes, to that periodic condition of rest known as sleep.

It should be realized that there are almost as many theories of sleep as there are investigators within the field. The three random theories that have been so briefly described above serve only to indicate the diversity of certain current points of view about sleep.

Photo by H. Armstrong Roberts

There are almost as many theories of sleep as there are investigators of the subject, but the generally held notion that a person requires eight hours of sleep daily is something less than an immutable law of nature.

No less interesting is the attitude that certain writers have taken about sleep. Some regard it not as a blessing but rather as a regrettable interruption of the waking state. Frank S. Hoffman in *Psychology and Common Life* * made the generalization that great minds spend less time in sleep than do persons of inferior powers. For those of you who, like Shakespeare (or was it Edward Young?), think of sleep as "nature's sweet restorer" the words of Hoffman may strike a somewhat discouraging note. He says: "The more perfect the development of the brain, the more complete its adaptation to its environment, the less friction and waste attending its exercise and consequently the less sleep. Civilization is the progress from sleep to wakefulness.

* New York: G. P. Putnam's Sons, 1903. $1.50.

The highest culture of which any human being is capable will be reached when the sleep and dream period is reduced to the minimum and the nobler activities of the soul are brought to the maximum of their efficiency and power."

The majority of us who are not constituted of pure brain and little else, but who are handicapped by the normal complement of arms, legs, and a torso, along with the usual number and kind of organs therein contained, will find a more sympathetic champion in Dr. Arnold Gesell who speaks of sleep as "a readjustment of the whole machinery of the organism . . . to protect the total and remote welfare of that organism."

This latter concept is given further amplification by another group of research scientists who consider sleep and wakefulness as two phases of the cycle of existence in which each phase complements the other, and in which those alternating phases, in the normal human adult, take on the pattern of a relatively regular sleep-wakefulness rhythm.

Even the most casual of observers cannot have failed to notice the disproportionate amount of time that the newborn spend in sleep. It is an almost continual oblivion that appears to be interrupted only when the baby is hungry, too warm, too cold, or is otherwise disturbed. As the child grows older, its sleeping habits become more highly organized. Instead of a continual series of four- to five-hour naps, there is a consolidation of these sleep periods into one long sleep phase during the night, followed by as many naps during the day as the age and general health of the child may indicate. As the child continues to grow, the naps are given up one by one, usually to the regret of an increasingly harassed mother, but almost always to the delight of the child whose curiosity and avidity for the experiences that await him during the day can hardly be contained. Whereas no adult in his right mind could be expected to leap out of bed at five o'clock in the morning, strap on a pair of roller skates, and whiz down two flights of uncarpeted stairs, banking smartly around the dining room walls and into the kitchen in hot pursuit of whatever breakfast food it is that makes champions, such forthright demonstrations of the desire to be up-and-doing are common enough among the younger set. These cheerfully explosive greetings to the new day are in marked contrast to the behavior of the newborn. Not only is the infant completely lacking in such expressions of enthusiasm but he even exhibits a positive and often obstreperous reluctance to waste any time at all in the waking state. He squawks and squalls. His tiny face screws up into a contortion of protest. Peace and full contentment come to him only when he relapses into that vegetative existence which we call sleep.

Photo by Harold M. Lambert

Whereas no adult in his right mind would be expected to leap out of bed at five o'clock in the morning . . . and whiz down two flights of uncarpeted stairs . . . such forthright demonstrations of the desire to be up-and-doing are common among the younger set.

The sleep requirements of the adult are something else again. Before we attempt to describe them, it should be understood that all further discussion is based upon certain broad assumptions. We assume that the majority of the readers of this article are members of the same general type of civilization whose sleeping period is taken in one piece rather than in bits and driblets at any time that strikes the fancy. For individuals of such a society, a solicitous "Did you sleep well?" is a question second in frequency only to "How do you do?" or "How are you?" In one sense it is almost synonymous with the other two, since the implication is that if you've slept well you are, as a result, feeling well. So clearly understood is the importance of refreshing sleep to the general physical and mental well-being that a great deal of attention has been given those factors that appear to affect both the quality and duration of sleep. Some of those factors are beds and bedding, ventilation and temperature of the bedroom, eating-drinking habits just prior to bedtime, and the establishment of regular sleeping habits.

With the abundance of "How To . . ." literature that has made its appearance in recent years — everything from "How To Play Golf in the Low Seventies" down to and including "How To Build A Summer Cottage out of Beer Bottle Tops" — it is rather a pity that a similar sure-fire prescription can't be written for a good night's sleep. You might imagine that a carefully controlled experimental investigation of the factors affecting sleep that were mentioned above would go a long way toward the establishment of such a formula. Not at all! Practically the only unqualified conclusion that has been drawn from these experiments, and a great many of them have been most intelligently conceived and executed, is that man, in his sleep habits, shows the same high degree of variability and individuality that he does in the selection of his neckties.

What could be more shocking to the literal-minded lover of pat generalities than the discovery that the notion "man requires eight hours of sleep" is something less than an immutable law of nature. It is, of course, nothing more than a conveniently expressed average. Some people do famously on five or six hours of sleep; others are not fully recuperated on less than seven. Still others find their optimum to be eight and nine, or even 10 hours of sleep. These differences are accounted for, among other things, by individual differences in temperament and metabolism. Even within the adult span of

the same individual there appear to be differences in the amount of sleep required. Older people, it has been noted, seem to need less sleep than they did during their middle years.

Similarly, any attempt to pontificate on the pros and cons of eating and drinking just prior to bedtime must result in statements so bristling with qualifications and exceptions that, for all practical purposes, they cancel themselves out. You probably know, or even may be, an individual for whom a sip of coffee and a bit of buttered toast adds up to a most harrowing pursuit by ghouls and goblins through the endless and vastly echoing corridors of the night. And then consider, if you will, those deeply, sweetly sleeping ones who, not 15 minutes before, washed down two onion-garnished, Liederkranz-smeared fried egg sandwiches with a schooner of beer. See how beatific their countenances — with what relaxed and languorous grace they lie. Not for them the hideous specter of a Headless Horseman nor even the ceaseless tossings of insomnia — but only undisturbed, health-giving sleep.

However exasperating and contradictory such typical examples may be, they do serve the excellent purpose of reminding us again that in any given situation involving man we must expect differing and even opposite reactions.

There is nothing intrinsically harmful in a light snack before bedtime. In fact, Walter B. Cannon, in his excellent book *Digestion and Health* † pointed out that such a snack acts as a check on hunger contractions of the stomach during the night and consequently eliminates disturbances from this source which so often interfere with sleep and produce restlessness. If any general rule for eating-drinking before bedtime is to be established, it might well be that of following the dictates of your own taste so long as they lead to the satisfaction of your sleep and general health requirements.

In the matter of beds, we apparently come closer to grips with reality. Here is something tangible, something that can be touched and tested. With the easy confidence that is so characteristic of dealings with the familiar, one scholar learnedly described the most suitable bed as that which exerts equal and opposite pressures to the pressures that the recumbent body exerts upon it. It is to be hoped that you will select a bed of this sort. Any other type is apt to fall within one of two questionable categories. One, "The Wishy-Washy," is a bed so miserably lacking in spirit that any attempt to use it for more than decorative purposes will result in a repeated series of crashings through to the floor until either the bed or the thwarted sleeper is unable or unwilling to continue. The other, even worse, has been appropriately named "The Challenger" by an anonymous Chicago social worker. This model comes equipped with a highly developed competitive instinct and a four-cycle, air-cooled, gasoline-driven ejector capable of delivering a vertical thrust at 375 horsepower. Its interesting possibilities, even to the mechanically naïve, should be obvious.

What you want, of course, is a bed that will permit you to sleep in a completely relaxed manner — one whose construction or shape sets up no muscular tension but which allows you to float in a dreamless state of utter unawareness. How hard or how soft such a bed should be is a matter of your own taste.

The word "taste" has been used a number of times to indicate the method by which an individual may choose from among several conditions the one condition that most favors his particular sleep requirements. It should be clear that such a preference or manifestation of taste is not merely an affectation but actually represents a real need that has been recognized by the individual concerned. This recognition often comes only after a period of personal trial and error. For example: Mr. X has discovered that he requires nine hours of sleep to be at top efficiency for the demands that his daily work makes upon him. He rests most comfortably in a bed that is rather stiff and firm. Even during the winter he seldom uses more than one sheet and one blanket to cover himself. He claims that anything more oppresses him with its weight. He likes lots of fresh air. On the few occasions that he failed to open his bedroom windows, he awoke feeling heavy-lidded and depressed. Mr. X has a hearty appetite but he has long since given up his indulgence in bedtime snacks. For him, they invariably resulted in sleeplessness. Once asleep, Mr. X is not easily disturbed. Voices in the next room, the closing of a door, a sudden thunderstorm — none of these things awaken him. As Mr. X would put it, "I slept like a log." Mr. X didn't sleep like a log at all. He changed position a number of times during the night, he readjusted the covers, he muttered softly to himself, but he didn't wake up.

The various factors mentioned above are, in a sense, like the pieces of a mosaic that have been hand-picked and fitted together by Mr. X into a pattern that is just right for his particular and individual sleep requirements. His only criterion in making that selection was to ask, "How do these things affect the quality and duration of my sleep? Do they contribute to it or do they detract from it?" In answering those questions to his own positive satisfaction, Mr. X simultaneously established a personal formula for restful, health-giving sleep.

It should be increasingly clear that any attempt to achieve a regular routine of restful and sufficient sleep does not depend upon an understanding of the physiological changes that precede sleep or that transpire during sleep. Nor is it necessary to be conversant with the more acceptable theories of sleep. But it is of paramount importance that we recognize those individual requirements and conditions, the satisfaction of which normally assures a good night's rest. In this respect, you are your own best investigator and counselor, for upon your own daily observations of the conditions under which you sleep, and upon your own estimation of the wholesomeness of that resulting sleep, you can best determine what corrective modifications may be required. However obvious this statement may appear, it is one that deserves the greatest emphasis. Unfortunately, far too many individuals are prone to reject the obvious in favor of the well-intentioned but often ill-advised suggestions of their friends. The alarming increase in the indiscriminate use of barbital and other hypnotics to induce sleep is today's tragic example of how dangerous such irresponsible suggestions may be.

When, like Mr. X, you have discovered your own formula for wholesome sleep, and when you have established that formula as a regular habit of your daily existence, it is probable that you'll be content to let the laboratory investigators continue their efforts to unravel the mystery of sleep while you blissfully and unconsciously practice it.

† New York: W. W. Norton and Company, Inc., 1936. $2.00.

What's on the Worker's Mind?

Enjoying High Wages, Good Working Conditions, and Leisure American Workers Look to More Stable Employment with Security upon Retirement

By Paul Meadows

DURING the first two years following World War I, Whiting Williams made a journey among American workers. Formerly personnel director of the Hydraulic Pressed Steel Company, he wanted to know, as a worker himself, the problems of industrial workers. He took one employment after another, in different parts of the country and in different industries. His two-year tour he described in a vigorous and informing book, published in 1921, *What's on the Worker's Mind?**

It is a good question, it is important, and a great deal of the economic and political future of the industrial West is involved in it. A prime difficulty about it, of course, is that there is no really reliable way of knowing whether or not one has an answer. If there is such a thing as the mind of the workers *en masse*, one can be certain that it will change, on some matters and to some extent at any rate. The method Williams used inspires confidence in the answers one receives no more than does a newspaperman's quick survey, written after a few weeks' visit to Russia and purporting to tell all. Improvements have been made on Williams' method since his day. To cite a few instances: there are the studies of the industrial psychologists, the elaborate investigations of the specialists at the Hawthorne plant of the Western Electric Company, the work of the Yale Institute of Human Relations, and last, but certainly not least, the recent reports of the industrial sociologists.

Social scientists are still unprepared to give unqualified support to a new device for discovering what's on the worker's mind — the public opinion poll — but they respect it, and they have high hopes for it. Critics of the polls have been justifiably concerned with certain problems of poll procedure and poll interpretation, mainly those involving bias. Their caution should serve as a precaution for anyone interested in the data collected by the polling agencies. At the same time critics would not do away with the polls, and all of them look forward to their extension. One leading expert has recently made a plea for world surveys by opinion testers, and the journal, *Public Opinion Quarterly*, regularly summarizes the findings of 13 different national polls, nine of them foreign. With adequate safeguards against prejudice, the opinion polls may be regarded as an absolute essential in a democratic industrial society. Their popularity can be explained in part in terms of their usefulness to special interest groups, and in part in terms of their rather obvious usefulness as guides to the general public.

During the last decade the national polls of labor opinion about labor problems have piled up a wealth of information about the mind of the worker in America. It is true these reports have focused on specific questions, and the flow of national and international events has conditioned the opinions expressed at any time.† Moreover, rank and file sentiment in any sector of our society about any problem tends to get its cues from leadership; certainly it tends to be mobilized by leadership from time to time. An expressed opinion, therefore, bears no one-to-one relationship to a persisting mind-set, and it does tend to be changed. The public opinion polls will not tell us fully what's on the worker's mind. Probably such opinion sampling techniques are to be regarded only as superficial and perhaps not too dependable, but they help. It may be hoped they will acquaint us, to some extent, with that uneven and inadequately surveyed terrain called labor.

Whiting Williams was very deeply impressed, in his conversations with American workers almost a generation ago, by the fact of "the fundamental importance of the daily job," which he called "the axle" of the worker's world. Williams moved among the workers during a period of unemployment; their obsession with the job can be easily understood. However, the circumference of the worker's world in an age of mass communication and mass unionization has greatly expanded during the interwar years. Do the polls now suggest a different picture of labor thought about the job?

The Importance of the Daily Job

They report a certain basic satisfaction with it. The Roper poll (for *Fortune* magazine) found, in the spring of 1947, that three-quarters of American laborers agreed that their jobs are interesting nearly all or most of the time; a fifth regarded their work as moderately or completely dull. According to Roper, the American laborer was also inclined to feel, as expressed in four out of five interviews, that his job is really essential to the success of the company. This sentiment was, in fact, stronger in the big factories than in the small companies. Apparently, the job is still fundamental, as Williams observed.

* New York: Charles Scribner's Sons. $2.50.

† The literature on the polls is extensive. Most of it centers on two questions: whether poll data are representative and whether poll interpretations are fair. Polling agencies are, it is frequently contended, inclined to bias, conscious or unconscious, in the selection and phrasing of questions, in the interview methods employed, and in the generalizations from data. Two of the best reviews of opinion studies are: A. M. Lee, "Sociological Theory in Public Opinion and Attitude Studies," *American Sociological Review*, 12 (June, 1947), 312ff.; A. Kornhauser, "Are Public Opinion Polls Fair to Organized Labor?" *Public Opinion Quarterly*, Winter, 1946–1947, 484ff. The latter article, surveying 155 questions about unions, concluded that three-fourths of all American Institute of Public Opinion (Gallup) questions and about one-third of those from the other agencies "are in the negative direction." However, since Kornhauser illustrates rather than demonstrates the process by which he arrived at this sweeping generalization, his conclusion is not wholly tenable.

However, the present-day workingman is apt to qualify such generalizations about his work. Asked by Roper if he thought his job too simple to bring out his best abilities, he said, in one case out of four, that it was. To the more revealing question, "Does your job really give you a chance to try out ideas of your own?" almost half (49 per cent) said "no," and the percentage of those saying "no" was considerably higher among those workers who thought their job dull most or all of the time. Nevertheless, the worker will probably not say now, as he did then to Williams, that he is worn-out at the end of the day. Two-thirds of the workers told Roper they were not, although more than half (57 per cent) of those who find their work monotonous complained of fatigue. Improved mechanical and administrative technology in the last quarter of the century has undoubtedly been responsible for this apparent change.

One notes again and again in the polls a certain sophistication about the job. For example, contrary to the American mythology on the subject, the quality and energy of the performance at work do not pay off in promotion or advancement, according to half of the workers questioned by Roper in the winter of 1946–1947. Four years earlier he had found that almost two-thirds (61.6 per cent) of factory workers thought that their chances for advancement were poor or only fair, and men under 34 were almost as skeptical (63.6 per cent) as men 50 and over (76.6 per cent). Moreover, the prospect of going up the ladder of management — for instance, becoming a foreman — seemed quite uninteresting to 58 per cent of the workers who said, in fact, that they would not like to be a foreman. Almost half of the one-third who indicated that they would like to become a foreman also said that they do not expect to be advanced to that position. Interestingly enough, slightly more than a fifth (21 per cent) of those under 40 years of age, as against 17 per cent of those over 40, thought that they would ever get beyond a foreman's position. Less than half of the college-trained factory workers thought that they would advance beyond that rank.

Williams came back from his observations in the field perturbed by a bad morale situation among American workers. The polls, particularly that of Roper's, also encounter a morale problem, although they have marked it off analytically in a manner somewhat different from that of Williams'. A man's morale is good, it seems, if he is interested in his job, is not overworked, feels secure for old age, has confidence in his ability to advance, and believes that merit is recognized and rewarded. Roper found in the late spring of 1947 that three out of five American workers can make good on three or more of these criteria of good morale; the other two he designated as below the average, and in another connection he spoke of them as miserably adjusted. Workers were asked: "If you should be able to go back to the age of 15 and start life over again, would you choose a different trade or occupation?" Somewhat more than half (57 per cent) said they would.

Poll data seem to show that job satisfaction is not entirely a matter of possessing all the factors presumably favorable to high morale. For only half of the factory workers who had all five of the high morale factors said that they would stay with the same kind of work if they could start all over again. The best bet for morale seems to be a worker who is satisfied with the firm for which he is employed and who is also satisfied with his kind of work. Yet it is most enlightening to learn that even though seven of ten (71 per cent) of the American factory

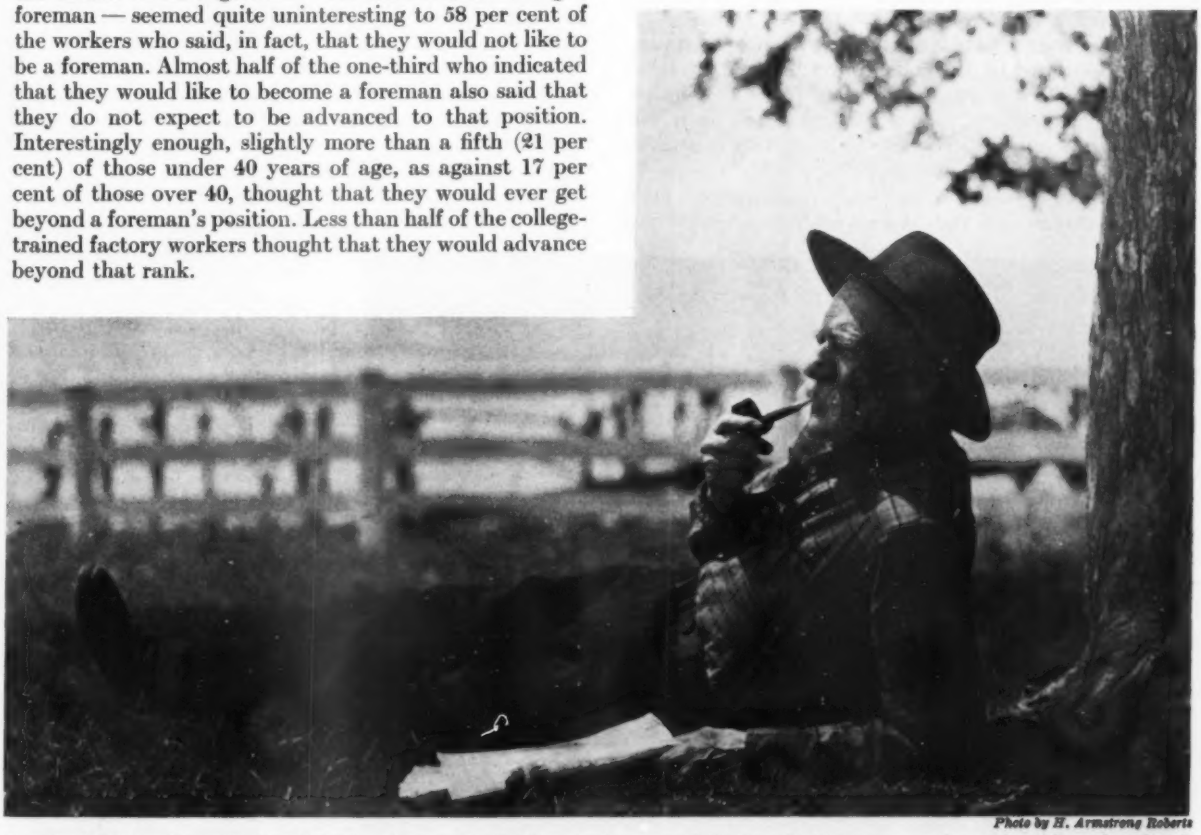


Photo by E. Armstrong Roberts

Security in old age is an objective of the American worker but there is almost equal division of opinion among the workers themselves that financial independence can be achieved at 65 years of age. A poll conducted in the spring of 1947 indicated that 42 per cent of the factory workers thought it likely that they would be able to retire in reasonable comfort at 65 years of age, but 41 per cent thought it unlikely that they would be able to do so.

workers are satisfied with their company, only one in eight (13 per cent) possesses all five of the favorable morale factors listed by Roper. The job is, it seems, still fundamental in the sense that it appeared to be to Williams at the close of the first World War.

Management and the Worker

In his trip throughout American industry, Whiting Williams noted a widespread ignorance on the part of the workers about the plans and purposes, the aims and ideals, and even the character of his employer, the company. He found great rifts between management and labor — hostility, suspicion, and fear.

Poll data seem to indicate a slight but by no means pronounced improvement in labor-management relations since that time. Asked in the late spring of 1947 if "your company is about as good a place to work as there is," seven out of ten workers said "yes." This attitude may be expressive simply of resignation, but there are probably other interpretations.

The polls show a high correlation between contentment with the type of work and company loyalty. Yet American laborers have misgivings about their employers. Less than six per cent of them think all employers are fair to their employees concerning hours, working conditions, wages and salaries, and collective bargaining. Only some, or about half, of the employers would win a vote of confidence in their fairness in these matters, although less than half of the workers polled would express such opinions on such a vote.

One grievance, commonly given circulation by unions and substantiated by the polls, concerns the attitudes of employers toward unions. Asked in the fall of 1946 if they felt that management has in its ranks some men who are trying to render labor unions completely powerless, half of the American union workers said there were "a few" such persons, and a fourth said that "most" managers had this motive. Only one in eight (13 per cent) held that there were practically no managers trying to do this.

American workers want a voice at the management conference table in order that they may be represented. Three out of four factory workers, polled in February, 1943, welcomed this proposal as a good idea. As to what a worker's representative should say in such a situation, the only matter about which factory workers were relatively noncommittal was payment of dividends. On all other questions, — that is, working conditions, wages, production plans, promotion, salaries of management — 50 to 97 per cent of the respondents were cordially in favor of having an opportunity to "say something."

Most laborers (56 per cent) are agreeable to the notion that the foreman should join a labor union, according to a Gallup survey in May, 1945. This same question had been asked two years earlier, in the summer of 1943, and it revealed that skilled workers were more responsive to this suggestion (58 per cent) than the semiskilled or unskilled (50 per cent).

Unionists as Economic Men

Unionization is one form which the attitude toward management takes. People who belong to unions are, of course, more sure of the importance of unionization in order that labor interests be protected than are those who do not belong. However, even nonunion workers are not unequivocally opposed to the union movement. As against 59.6 per cent of the unionists, half of the nonunion workers agreed with two check list statements which affirm the need for unions under any or present circumstances, according to a Roper report in June, 1940. And in a sample of opinion made in the winter of 1942, Roper found that only half of the nonunion workers would rather work in a place with no union, while two out of five (41.5 per cent) expressed preference for some kind of union shop, local or national.

It appears that Williams' speculation summarizing his observations at the conclusion of (*Continued on page 342*)

As expressed in four out of five interviews, the American worker feels that his job is important. Three-quarters of American workers feel their job is interesting nearly all or most of the time. Essential to our modern industrial form of life is a sense of motion and progress, and self-respect coupled with pride in accomplishing the daily task.

Photo by Harold M. Lambert

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Foundry Foundations

DEMANDS which World War II made upon the foundry industry disclosed the great need for college-trained men in this field, and the various foundry, trade, and technical associations acting separately and collectively have indicated their intention for supporting a broad program of training in institutions of higher learning. To meet the demands for professional training for the foundry industry, Thomas K. Sherwood, '24, Dean of Engineering, has announced the establishment at the Institute of a foundry program combined with the courses in metallurgy, mechanical engineering, and business administration.

Expansion of the Institute's program in foundry training has been facilitated by the active interest of the Steel Founders Society of America. To aid in providing adequate facilities for teaching and for student research, the Society is installing at M.I.T. a three-phase, electric-arc furnace, as well as numerous other pieces of equipment. In addition, four scholarships at $1,500 each have been established.

The program is also being aided very materially by a grant for purchase and installation of equipment from the Foundry Educational Foundation, a joint organization for promotion of foundry education in America comprising the American Foundrymen's Association, the Malleable Founders' Society, the Gray Iron Founders' Society, and the Foundry Equipment Manufacturers Association. The Foundation also provides five undergraduate scholarships of $700 each.

It is hoped that M.I.T. will have one of the finest foundry laboratories for teaching and research in America. The foundry laboratory will be a part of the newly created Division of Mechanical Metallurgy under Professor John Wulff, which also includes the laboratories in welding, hot and cold working, and powder metallurgy. The division is administered by the Metallurgy Department under Professor John Chipman, Head of the Department of Metallurgy, with the assistance of Professors Erwin H. Schell, '12, and C. Richard Soderberg, '20, from the Departments of Business and Engineering Administration, and Mechanical Engineering, respectively.

Advanced quantitative aspects of foundry technology will be emphasized in Foundry Engineering, I, Iron and Steel, and in Foundry Engineering, II, nonferrous, a subject which will be developed later after a firm foundation is provided in the prerequisite subjects, Engineering Metals and Metal Processing. Foundry teaching and research will be under the direction of Howard F. Taylor, 2–46, Associate Professor of Metallurgy, formerly of the Naval Research Laboratory, Washington, D. C.

In brief detail a student in any of the three courses, who desires to fit himself for the foundry industry, will make substitutions and elective choices of pertinent subjects, within the framework of standard curriculums. His training will be of the same sound quality regarding science and the humanities as obtained by other students.

Gordon S. Rentschler: 1885–1948

ONE of its most able and valued members was lost to the Institute's Corporation on March 3, when Gordon Sohn Rentschler, Chairman of the Board of the National City Bank of New York, died of a heart attack in Havana, Cuba, while on a much needed vacation.

Mr. Rentschler was born on a farm near Hamilton, Ohio, on November 25, 1885, the son of George A. and Phoebe Schwab Rentschler. He studied in the schools of Hamilton and matriculated at Princeton University from which he was graduated, as president of his class, in 1907. Starting as a laborer in the firm established by his father, he became president of the Hooven, Owens and Rentschler Company and associated foundry and machinery manufacturing firms in Ohio. Among the products of these companies was machinery used in the sugar industry. Mr. Rentschler's duties required him to spend much time in Cuba where he studied all phases of the sugar industry. As a result of his intimate knowledge in this field, his services were sought in 1921 by the National City Bank of New York, which had extensive interests in Cuban sugar. His abilities, enthusiasm, and interest in people were immediately recognized, with the result that

GORDON S. RENTSCHLER

Mr. Rentschler was elected a member of the Board of Directors of the National City Bank of New York in 1923 and two years later was made a vice-president. In 1929 he became president and served in that capacity until he assumed the chairmanship of the board in 1940.

In addition to heading the National City Bank of New York, Mr. Rentschler was a member of many leading corporations, including the City Bank Farmers Trust Company, the International Banking Corporation of New York, the Federal Insurance Company, the Home Insurance Company, and the National Cash Register Company. He was a director and member of the executive committee of the Union Pacific Railroad, a trustee of the Consolidated Edison Company of New York, and recently was elected a trustee of the Carnegie Institution of Washington headed by Dr. Vannevar Bush, '16.

Mr. Rentschler's most active outside interests were his life trusteeships in his Alma Mater and in M.I.T., both institutions of which he served enthusiastically for many years. He was a member of the Visiting Committee on the Department of Geology from 1937 to 1940 and served as its chairman during 1938 and 1939. He was a member of the Visiting Committee on the School of Architecture during 1943–1944, and was chairman of the Visiting Committee on the Department of Aeronautical Engineering from 1941 to 1948. In 1937, Mr. Rentschler was appointed a special term member of the Corporation and was elected a life member in the following year. He served as a member of the Committee on Finance since 1937, and since 1946 was a member of the M.I.T. Executive Committee.

State of "the Union"

SOME 800 Alumni who gathered at Walker Memorial on the evening of February 7 for the Midwinter Alumni Meeting of Metropolitan Boston heard President Compton tell of the progress on current projects on which the Administration is now working. The Review is happy to present extracts from Dr. Compton's address as follows:

The new Senior House is under construction although it has been slowed up by the severity of the winter weather. Every effort will be made to have it ready for occupancy by next October, though it may be impossible to meet this schedule.

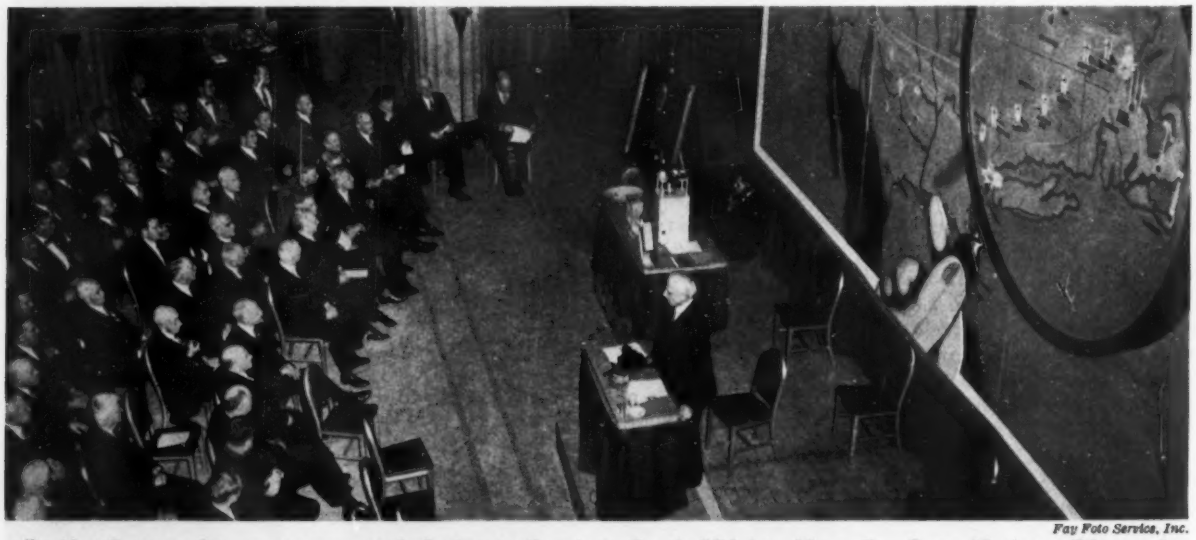
The foundations are installed for the athletic cage which will provide indoor space 200 feet by 160 feet for year-round athletics. The great roof trusses which are the key features of this building have been received in Boston and the cage should be ready for use by next fall.

Substantial progress has been made in the procurement of funds and equipment for the construction of the new Hydrodynamics Laboratory and Naval Towing Tank. The contributions totaling several hundred thousand dollars have come from several shipbuilding companies, manufacturers of hydraulic equipment, and interested individuals. This laboratory will be a great asset to our Departments of Civil and Mechanical Engineering and Naval Architecture and Marine Engineering.

I am glad to announce that we shall be able next summer to re-establish the very successful program of the Alfred P. Sloan Foundation Postgraduate Fellowships in Business and Engineering Administration which had to be discontinued during the war because the promising junior executives for whose benefit this program was instituted could not be spared from their positions in industry.

One of the most encouraging features of the present situation is the fine manner in which our undergraduate body, through its Institute Committee, has tackled the problem of re-establishing and improving the whole program of student self-government and extracurricular activities which were so much disrupted and partially abandoned during the war period. The students have been very earnest in this effort and their effectiveness has probably been enhanced by the increased experience and maturity which so many of them gained in war service.

The only unhappy feature of my report is the announcement of an anticipated deficit of about a half million dollars in next year's operations, in so far as we can at this time estimate operating income and operating requirements. This financial situation calls for careful and skillful planning by all concerned. It may be recalled, however, that as long ago as 1941 we estimated the reconversion from the accelerated educational program of the war years back to the normal peacetime program would involve a loss of three-quarters of a million dollars. This next year appears to be the time when the major impact of loss will hit us.



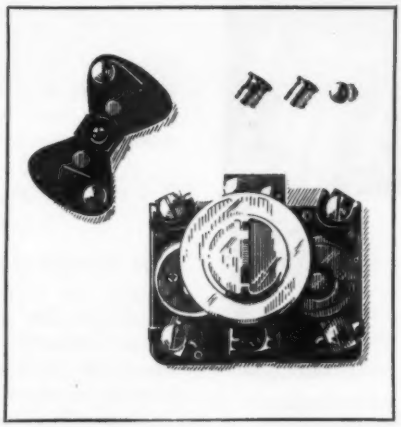
Fay Foto Service, Inc.

President Compton relates recent progress at the Institute to Alumni attending the Midwinter Metropolitan Boston Meeting on February 7. The large map was used in conjunction with telephone messages to various parts of the world over radio links (see The Review, March, 1948, page 272). At the corner of the platform is the portrait of Dr. James L. Tryon, formerly Director of Admissions at M.I.T., which was painted by and presented to the Institute by Mrs. Tryon.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

To most people, copper is just copper, and a familiar metal that can be handsome as well as useful. Revere, however, offers no less than six different coppers, each one having special qualities that set it apart from the others. One of these is Free-Cutting Copper, which can be much more easily and quickly machined than any other type of the metal. It is therefore an ideal material for the manufacture of machined parts requiring the high electrical or heat conductivity of copper. However, the metal is the highest priced of the six coppers, in cents per pound, and for that reason its economy is often questioned.



That this "expensive" copper is actually the most economical, when machining is involved, has been proved many times. For example, a company manufacturing electrical parts and equipment tried Revere Free-Cutting Copper first on a test basis, and then in standard production runs. Here are some results:

Part A: 5,760 pieces produced in 19.6 hours with no machine down-time, as against 10,425 pieces in Electrolytic Copper run in 66.6 hours with 11.8 hours machine down-time, plus use of three sets of dies. Saving per thousand, $1.81, including material and labor.

Part B: Saving per thousand, 77¢, including the material difference and direct labor. In addition, a saving of 18% in machine down-time.

Parts C & D: Both were redesigned, to eliminate a facing operation formerly required, now unnecessary due to the smooth surfaces produced in Free-Cutting Copper. No direct comparison is possible, but estimates are that these parts are being made four times as fast as they could be in Electrolytic.

In general, this customer found that there is a saving of at least 25% in machine time when using Free-Cutting Copper. Another important factor is worker enthusiasm; they like the metal because they no longer have to keep a constant close watch on the work to see that the turnings do not become tangled with the moving parts of the machine.

Thus it can be seen that Revere Free-Cutting Copper, though seemingly expensive per pound, is actually the most economical where machining is involved. In other words, we have here another example of the fact that "the best is the cheapest." Suppliers in every industry offer materials at varying prices, and it is suggested that no matter what you make, nor from whom you buy, it will pay you to investigate what is really "best" for your purposes. Price is not necessarily a guide to true economy. If you will permit your suppliers to study fabrication processes and end uses, perhaps from such mutual collaboration will come new ideas for reducing costs.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

☆ ☆ ☆

Executive Offices:

230 Park Avenue, New York 17, N. Y.

Notice The Centerlines: In all Curtis joints the fork slots are centered accurately and pin holes align perfectly so pins will intersect at exact center.

Universal joints *must run true* to insure smooth, troublefree, vibrationless operation of rotating power transmissions with minimum eccentricity.

Important:
The axes of driving and driven shafts connected by universals *must* intersect at exact center of joint. Both pins of a joint *must also* intersect at this common point. In connecting non-intersecting shafts either two single joints or one double joint should be used.

Centerless grinding of a finished joint *does not* make the joint run true.

Special production machines and precision methods designed and used by Curtis in manufacture insure close precision operation of every joint, whether block or ball type.

Be sure of the best—Specify Curtis Universal Joints

Write Dept. B-5

CURTIS UNIVERSAL JOINT CO. INC.

THE MATHEMATICS OF LIFE

(*Continued from page 315*)

the same vitamin D-free ration, but is exposed to sunshine (sunshine of sufficient intensity and duration generates vitamin D by activating precursors in the surface tissues). The second experimental group is shielded from sunlight, but is fed a ration with a certain amount of a particular form of vitamin D added. The objective is to determine the effects, if any, of the two sources of vitamin D. In an actual study several characteristics would no doubt be observed, but the table has been limited to a record of body weights.

As the table indicates, the animals were selected so that average weights of all three groups at the outset were approximately 28 kilograms. However, as the individual weights show, separate animals weighed as little as 26.0 and as much as 29.6 kilograms. Six months later the control lambs had gained an average of 10.8 kilograms; those in the sunshine group, 12.4 kilograms; and those in the vitamin D group, 14.2 kilograms. Since both experimental groups show greater average gains than the control group, a hasty conclusion might be drawn to the effect that both sunshine and vitamin D had promoted growth. But note again the wide variation among individual gains in any one group. Furthermore control animal number 2 gained 13.2 kilograms, whereas animal number 1 in the group with the highest average gain gained only 12.5 kilograms. This observation alone underlines the inadvisability of basing conclusions on unqualified averages.

Procedure for Evaluating Significant Differences

If neither sunshine nor vitamin D had any effect upon weight, the weights of the animals in all three groups would be part of the same universe, represented by a single normal distribution curve. If, on the other hand, one of the variables had an effect but the other none, or if both variables had identical effects, the animals would be drawn from two universes, each having a separate and characteristic normal distribution curve. Finally, if the two variables had two different effects, quantitatively, each of the three groups would belong to a different universe, hence to a different normal distribution. A procedure based on this principle makes possible evaluation of significance of the differences among the group averages. The result, identified as the probability or p value, is a measure of the probability that observed differences are due to chance factors, that is, factors other than those controlled experimentally.

The table shows that the sunshine group gained an average of 1.6 kilograms more than the controls. However, this difference has a probability or p value of 0.24, which means that the observed difference might be the result of chance factors 24 times out of 100. Contrariwise, the 3.4-kilogram difference between the average gain of the control group and that of the vitamin D group has a probability of only 0.006. This signifies that only six times out of a thousand would a difference of this magnitude, between experimental groups of this constitution, be attributable to chance. The table on page 315 shows, of course, the results of a hypothetical experiment.

(*Continued on page 330*)

HOW AMERICAN INDUSTRY CAN *Save $1,800,000 per month*

A challenge to every user of metal-joining equipment!

Today, the ratio of arc welding equipment in use in American industry is 80% d-c to 20% a-c. Yet actual operating figures prove that *a-c welding is faster, cheaper, better on four jobs out of five!*

Here is a challenge to every user of metal-joining equipment—a challenge to forget old concepts of welding costs and efficiency—*to reverse the ratio of a-c to d-c equipment in line with proved operating results.*

The potential savings are startling. Because a-c welding is 20% to 30% faster—permitting excellent welds at higher speeds on all classes of work—nearly $1,240,000 monthly can be saved in labor costs (at $1.50 per hour). Because a-c welding requires less power—giving 85% to 90% electrical efficiency as against 55% to 64% for d-c machines—the potential monthly power saving is over $500,000 (at 2c per kilowatt-hour). Because a-c welders require less maintenance and produce more work with fewer machines—potential monthly savings on maintenance total more than $60,000.

These are "boxcar" figures, to be sure. But they are backed up with facts. A Westinghouse welding specialist is ready to give you these facts, and show you actual dollars and cents savings possible in your plant by replacing d-c welders with modern a-c welding techniques and equipment.

To share in this great potential saving, contact your Westinghouse office and ask a welding sales engineer to call. Or write Westinghouse Electric Corporation, Dept. R, P. O. Box 868, Pittsburgh 30, Pa. J-85008

INVESTIGATE!

A-C Welding is just one of many new or improved electrical techniques for producing faster, cheaper, better. Westinghouse engineers can give you salient facts on others applicable to your industry, including:

- Induction Heating (metals)
- Dielectric Heating (non-metals)
- Infrared Drying
- Automatic Welding
- Resistance Welding

Write or phone your nearest Westinghouse office for details.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

MORE PRODUCTIVE POWER FOR INDUSTRY

THE MATHEMATICS OF LIFE

(*Continued from page 328*)

Observe that categorical answers are not provided, because in actual studies zero values of probability are not obtained, so that it can never be said that a particular difference could not be due to chance. Nevertheless, when, as in the difference between the average values of the control and vitamin D groups, chance might account for the observed difference only six times out of a thousand, an observation has been obtained that is a reliable basis for general conclusions. In contrast, when as in the other group-average difference of our hypothetical experiment, chance might be responsible for the observed changes as many as 24 times out of 100, little light has been shed upon the true effect of the variable under study. Thus the hypothetical study showed conclusively that vitamin D added to the ration, in the form and quantity used, increased rate of weight gain during the age period observed. With regard to the effect of sunshine, a conclusive answer did not result. A real increase in rate of gain may have been produced by sunlight exposure, but if so it was too small to be revealed significantly with the number of animals studied, having variability in initial weights and in rates of gain as shown.

This last observation points up an application of statistical procedure fully as important as the one of interpreting experiments; this is the application of setting up studies. With knowledge of certain characteristics of the experimental organisms and of the problem at hand, it is possible, by ramifications of the technique demonstrated, to establish in advance the size of experimental and control groups required to obtain conclusive results. Thus the biologist has a technique for making effective, economical use of experimental methods and results.

Other Applications

The procedure just demonstrated is but one facet of an extensive statistical methodology. This method and related ones, and still others based on different concepts, find everyday use in bacteriology, immunology, pharmacology, physiology, nutrition, taste and odor tests, agriculture, and animal husbandry. Nor is the utility of statistical procedures confined to the laboratory branches of biological research; such methods are indispensable in fields like demography, epidemiology, market research, psychology, and education.

Statistical analysis gained wide use in an engineering field, quality control of the mass production of materials having mechanical specifications, as a result of the unprecedented demand for precision products generated by World War II. Tolerances from exact dimensions or other specifications must be accepted if such products are to be made at high speed. Although tolerances do not detract from utility of the products when held within suitable limits, they make it difficult to know whether the manufacturing process is being satisfactorily regulated. In the absence of such regulation, product characteristics may suddenly begin to exceed allowable tolerances, resulting

(*Concluded on page 332*)

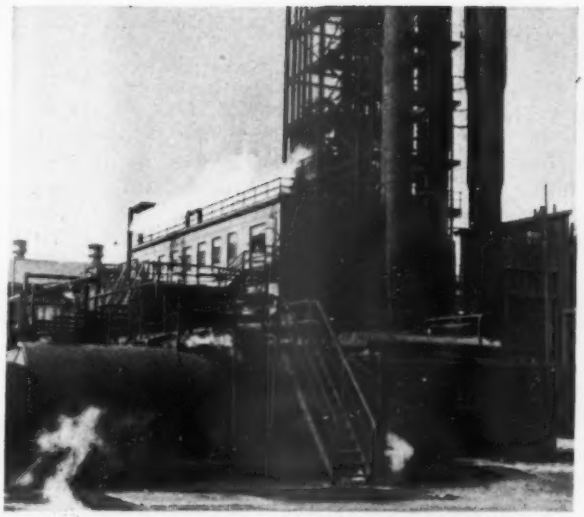
MULTIPLY MANPOWER · LEWIS-SHEPARD ·
TRADE MARK
ESTABLISHED 1915

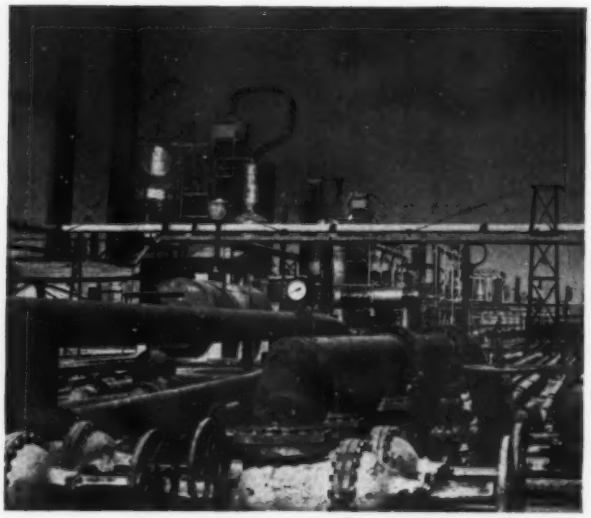
Sign of a Great Line of
Materials Handling Equipment
for 33 Years

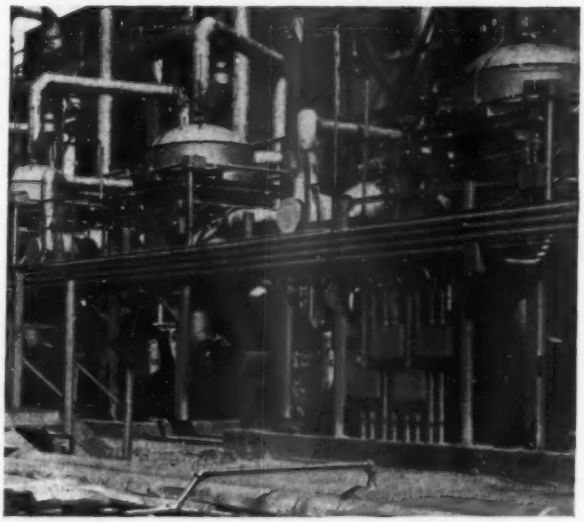
Multiply your Manpower, Speed up Production, Cut Overhead, and Save Money with Lewis-Shepard Power Fork Trucks, "JackLift," "JackStacker," and "JackTractor," Power Model Trucks, Hydraulic and Mechanical Hand Lift Trucks, "JackLift" Trucks, Pallet Trucks, Pallet Stackers, Portable Elevators, Cranes, Floor Trucks, Skids, and Racks.

Write for New Catalog of this Great Line

LEWIS-SHEPARD
PRODUCTS INC.
251 WALNUT STREET WATERTOWN 72, MASS.
REPRESENTATIVES IN PRINCIPAL CITIES CONSULT YOUR PHONE DIRECTORY







BETTER RESULTS
from expertness in all three

Chemical manufacture, petro-chemical manufacture, petroleum refining—they're all related under the common denominator of *process industries*.

Whether their operation embraces distillation, brewing, extraction, absorption, fractionation, or other process *engineering, experience in all of them is certain to heighten expertness in any one of them.*

Badger is a concern with long and wide experience in each of the three fields mentioned above. It includes process engineering, design engineering, construction engineering, procurement of materials, installation of equipment, and initial plant operation. It covers hundreds of products—some new; some old; some requiring most intricate and special manufacturing equipment; some produced in enormous quantities where every last operating cost factor is of prime importance.

Thus, a Badger development or improvement in one field can often be adapted with distinct advantage to a project in another field. In Badger's *expertness in all three* fields, your engineering department can draw on a wealth of outside information and skills toward getting the best possible results from the new plant or unit YOU have in prospect.

E. B. BADGER & SONS CO. Established 1841

BOSTON 14 • NEW YORK • SAN FRANCISCO • LOS ANGELES • LONDON

Process Engineers and Constructors for the Chemical, Petroleum and Petro-Chemical Industries

A SUBSIDIARY OF STONE & WEBSTER, INC.

CO_2

GAS . . . LIQUID . . . SOLID (Dry Ice)

THE LIQUID CARBONIC CORPORATION
3100 South Kedzie Avenue, Chicago 23, Illinois

U. S. A.
28 Producing Plants
More than 50 Distributing Points

CANADA
Halifax to Vancouver

OVERSEAS
England, Cuba, Mexico, Venezuela, Colombia, Trinidad, Brazil

Liquid RED DIAMOND Gas and Dry Ice

TRADE MARK
HEVI DUTY
REGISTERED U S PAT OFFICE

Hevi Duty Electric Co.

Electric Heat Treating Furnaces
Surges Dry Type Transformers
MILWAUKEE 1, WISCONSIN

Hevi Duty Precision Electric Heat Treating Furnaces are built in a large variety of types and sizes — for many heat treating operations — with temperature ranges to 2500° F. (1371° C.). They are standard production equipment in many national industrial plants.

Write for descriptive bulletins

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

THE MATHEMATICS OF LIFE

(*Concluded from page 330*)

in rejection of an undue proportion of output. But recognition of the fact that mechanical characteristics of mass-produced materials follow the normal distribution (or other mathematically definable distributions) has enabled rigid control to be exercised. First the process is studied intensively to establish limits of the distribution. Subsequently periodic spot checks of products are made; only when variability exceeds the limits of the established distribution need trouble be suspected and looked for.

Properly Used, Statistics Can Save Lives

Even in the biological fields where statistical methods first proved their value, these methods have still to attain their full utility. Consider the medical sciences alone: clinical studies are extreme examples of research that must be done with limited numbers of individuals. Yet in the absence of statistical procedures physicians have been forced to evaluate their results by means of estimates, often of a highly subjective nature, based upon observations of a few patients. But in the field of medicine adoption of statistical methods is advancing apace. At the last meeting of the American Public Health Association, for example, a statistical procedure called the apportionment method was offered for use in evaluating treatment of conditions such as advanced cancer. This method was proposed as an improvement over the classical alternate case procedure, whereby standard therapy and a new treatment are tried on alternate patients as they are admitted to the hospital. Either procedure ultimately reveals equally well which of the two treatments is the better; but the apportionment method permits application of accumulating knowledge as it is gained, rather than waiting until the conclusion of a series to decide which treatment is more effective. By reviewing clinical experiences in which the alternate case procedure had been used, the originator of the apportionment method was able to show that, in the light of how patients had fared on standard and experimental therapies, significant reductions in mortality could have been accomplished by use of the apportionment method.

Thus further development of statistical procedures, and their wider application to the biological sciences, may be expected not only to promote human welfare but actually to extend the human life span.

BIBLIOGRAPHY

For guidance in understanding statistics, without consideration of theory:

Butsch, Russell L. C., *How to Read Statistics* (Milwaukee, Wisc.: Bruce Publishing Company, 1946), $2.50.

Elementary theory, without mathematical derivations:

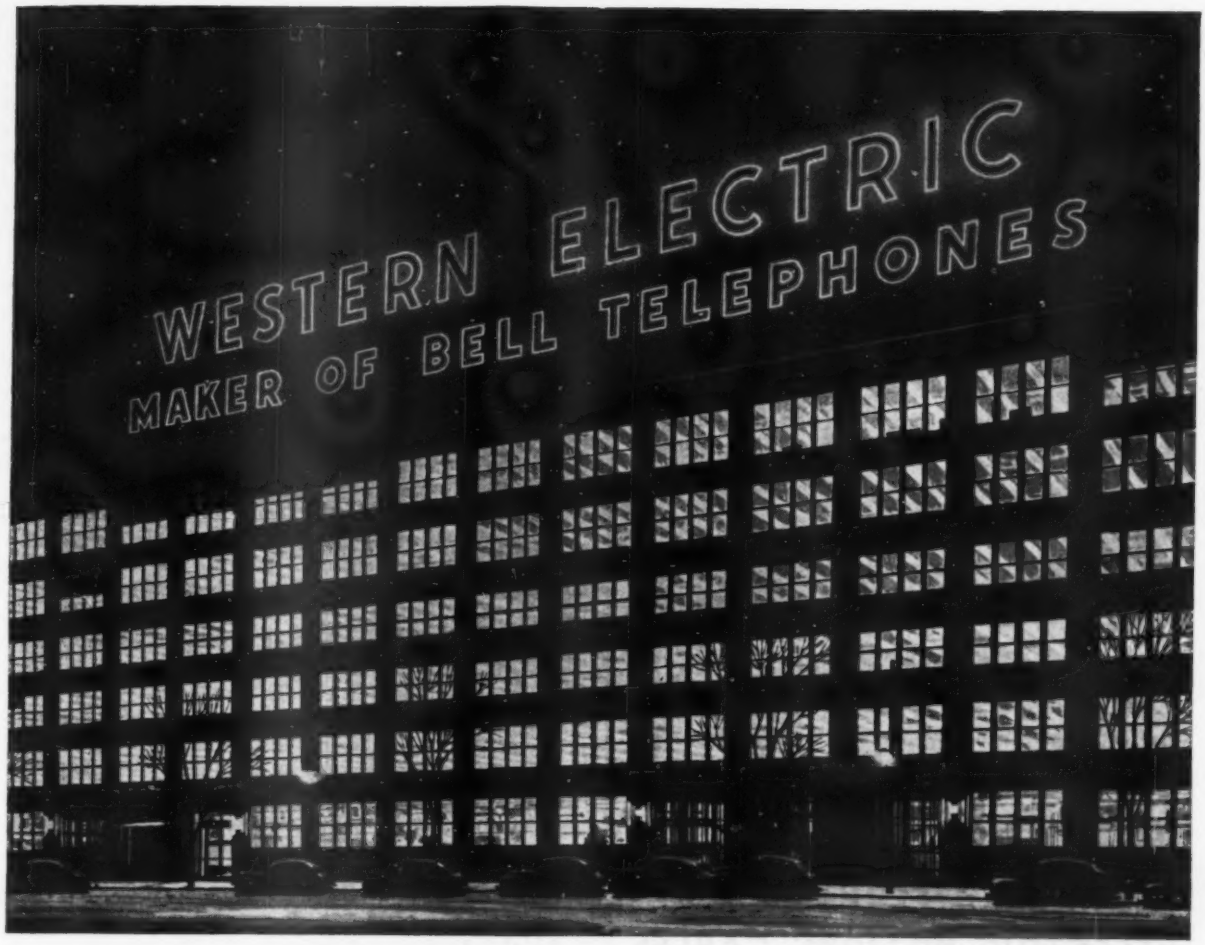
Smith, G. Milton, *A Simplified Guide to Statistics for Psychology and Education* (New York: Rinehart and Company, Inc., 1946), $1.25.

More detail about theory and derivations:

Fisher, Ronald A., *Statistical Methods for Research Workers*, 10th edition (Edinburgh: Oliver and Boyd, Ltd., 1946), 16s.

Statistical methods for manufacturing quality control:

Shewhart, Walter A., *Statistical Method from the Viewpoint of Quality Control* (Washington: United States Department of Agriculture, 1939).



What's back of that name . . . for YOU?

Back of the name Western Electric are 130,000 men and women who help make your Bell Telephone service the *world's best*—at the *lowest* possible cost.

Where are they? What do they do?

They're in factories in 18 cities, making vast amounts of telephone equipment designed by their teammates at Bell Telephone Laboratories.

They're all over the map, buying all kinds of Bell System supplies from other manufacturers.

They're at 29 distributing houses, filling orders from Bell Telephone companies for apparatus and supplies.

More than 31,000 of them are in mobile crews installing intricate central office switchboards and equipment.

In doing this huge job—one of the most complex in industry—Western Electric people are contributing daily to the efficiency and economy of your Bell Telephone service.

MANUFACTURER... of 43,000 varieties of telephone apparatus.

PURCHASER... of supplies of all kinds for telephone companies.

DISTRIBUTOR... of telephone apparatus and supplies.

INSTALLER... of telephone central office equipment.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Reg. U. S. Pat. Off.

Samson Cordage Works

Boston 10, Mass.

Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.

SPOT CORD

Reg. U. S. Pat. Off.

Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

SIMPLEX - TIREX ELECTRIC WELDING CABLES

Here's real welding-wise construction! It gives you a cable that's both flexible and tough. It assures you of savings in time, labor, and money on electric welding work.

Extreme flexibility is obtained by making conductors of many threadlike copper wires closely stranded together. It reduces drag and wrist fatigue and contributes to fast, efficient welding even in cramped locations.

Clean stripping is facilitated by a separator of soft cotton braid which does not bind the conductors nor hamper their flexibility.

Resistance to abrasion, moisture, grease, oil, and acids is furnished by a "cured-in-lead" jacket of Selenium Neoprene Armor. The jacket is not easily cut, will not support combustion, and provides insulation with essential electrical stability.

SIMPLEX WIRE & CABLE CO.

79 Sidney St., Cambridge 39, Mass.

ÉVARISTE GALOIS

(*Continued from page 318*)

lieutenant-general of the Kingdom, and in 1830 he was proclaimed King. Here was an intelligent man, kind of heart but of feeble character. The discontented people whose rights were reduced to almost nothing by his two predecessors showed their rage everywhere. It was in these stormy atmospheres that Galois lived, suffered, and worked at his mathematics.

Galois' struggles with politics led him to hope that he would find sympathizers, and so he wrote a letter to the *Gazette des Écoles* intended for the students and principal. He said, therein: "I ask nothing of you for myself, but speak out for your honor, and according to your conscience." There was no answer because those to whom he made his appeal probably had neither of the virtues he believed they had, or should have had if they were free men. Rejected, he turned to his real work.

Galois had been expelled from the École Normale and was now destitute. Food and lodgings were offered but he refused to accept charity. He lived on what he could gather at the poor restaurants in the neighborhood of the Pantheon and slept on benches on the *quais*. He tried to deliver lectures in the rear of Caillot's book shop in the Rue de la Sorbonne. He offered lessons in advanced algebra but found few pupils. These lessons were to have included Galois' imaginaries, the theory of the solution of equations by radicals, and the theory of numbers and elliptic functions treated by pure algebra. All of these were his original work. He tried very hard to sell the gold taken from his own mind to the intellectual market but there were no buyers. His great and brilliant discoveries went begging for asylum.

It was at this time that the academician Poisson offered encouragement to Galois and requested a memoir for the Academy of Sciences. At the request and encouragement of the academician Poisson, Galois took new hope, recast the memoir he had sent to Fourier, and submitted the new memoir to the Academy of Sciences on the "General Solution of Equations," known today as "The Galois Theory." Poisson kept this manuscript for four months and then, after several reminders by Galois, returned it to him with the brief single word "incomprehensible." This was, to say the least, an unusual decision for a man of the stature of Poisson. How could he have reached such a conclusion if he had really studied the memoir? Perhaps it went beyond his understanding and he spoke his innermost and honest conviction when he said that it was, to him no doubt, incomprehensible! This decision was a great blow to Galois who now began once more to devote his efforts to revolutionary politics. He preambled his revolutionary conflagration with these words: "If a carcass is needed to stir up the people, I will donate mine." And now he commenced to stir things in politics as if this were needed.

On May 9, 1831, some 200 *Républicains* held a banquet protesting against the royal order disbanding the artillery of which Galois was a member. Toasts were drunk to the Revolution, and here Galois, glass in one hand and an open pocketknife in the other, rose from his seat shouting, "To Louis Philippe." This denunciation frightened some of those present and they left — including Alexandre Dumas who escaped via an open window. But a majority

(*Continued on page 336*)

NOW

Temperatures Close to ABSOLUTE ZERO in any Research Laboratory

The Collins Helium Cryostat . . .

. . . opens a new era in low-temperature research. Now cryogenic workers can concentrate on *using* low temperatures, rather than on getting them. It eliminates the time and expense needed for especially designing and building equipment in the laboratory. In but a few months, installations in leading university, government and industrial organizations have more than trebled the number of laboratories in the United States where very low temperatures can be maintained.

The COLLINS HELIUM CRYOSTAT is made possible by wartime and postwar advances in applied thermodynamics. The first equipment supplied on a ready-to-use basis for liquefying helium, and other gases, it maintains temperatures down to 2° Kelvin and liquefies one liter of helium per hour. With Bitter Magnets, which can be supplied, temperatures a few thousandths of a degree above absolute zero can be reached. The COLLINS HELIUM CRYOSTAT was first developed by Dr. Samuel C. Collins of M.I.T. The present design, which can be operated without the attention of scientific personnel, was developed under the direction of Dr. Howard O. McMahon at Arthur D. Little, Inc. Bitter magnets were designed by Dr. Francis Bitter of M.I.T.

In addition to its regular operations as a consulting industrial research organization, Arthur D. Little, Inc., has undertaken to construct units of the COLLINS HELIUM CRYOSTAT for research laboratories.

For full technical information, write to:

Arthur D. Little, Inc.

Chemists—Engineers

30 Memorial Drive

Cambridge 42, Massachusetts

Assistant

RESEARCH DIRECTOR

Are you confined in a highly functionalized laboratory? Do you want to broaden your experience by more general business contacts both within and without a laboratory? Do you want to carry your developments beyond the bench and launch them into the manufacturing and sales departments? Are you an entrepreneur?

If you have a sound scientific education with chemical emphasis and also have broad general interests with proven ability to inspire others and get things done, we may have the scope you desire as assistant research director. Well-established company with long record of growth and successful research.

Apply only if you have top record of success in school and business. Substantial salary.

Reply Box F

THE TECHNOLOGY REVIEW

M.I.T. Cambridge 39, Massachusetts

THE ANSWER

Diefendorf approaches every gearing problem with a background of exclusive industrial experience. A resourceful engineering staff consistently maintains standards of precision manufacture. All metals and non-metallics.

•

DIEFENDORF GEAR CORPORATION
Syracuse 1, New York

DIEFENDORF GEARS

ÉVARISTE GALOIS

(*Continued from page 334*)

of the younger *exaltés* approved his threats, repeated after him, "To Louis Philippe," and finally finished the evening by dancing around the Column Vendome. Galois became a hero for the moment but the following day he was arrested in his mother's home and put in prison.

A clever lawyer devised an ingenious defense based on the claim that Galois had in fact said, "To Louis Philippe — if he turns traitor." The presence of the open knife was easily accounted for by saying that Galois was using it to cut chicken. During the trial Galois showed a contempt for the court and his accusers and launched a hot tirade against the forces of political injustice. The judge, touched by the thought of his own children, warned him that he was not helping himself and even silenced him. The prosecutor argued over the question of whether or not the restaurant was a "public place" when used for a semiprivate banquet. On this point of the law hung the liberty of Évariste Galois. After a short deliberation the jury, moved by the youthfulness of the defendant, returned a verdict of "not guilty." Galois picked up his knife, slipped it into his pocket, and left the court room without a word. Was this the end of his troubles? Hardly.

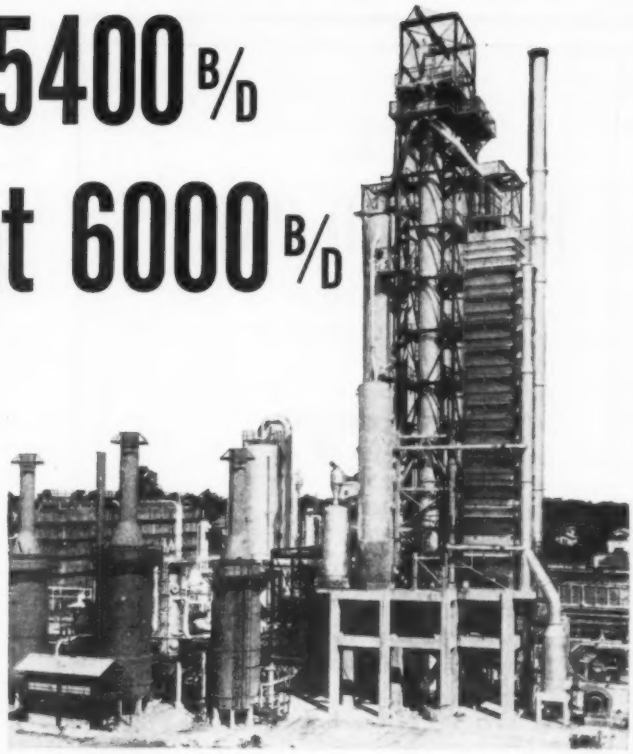
Less than a month from the date of his liberation he was again arrested as a precautionary measure. The *Républicains* were to hold a celebration and Galois, being considered a dangerous radical in the eyes of the police, was locked up on no charge whatsoever. The newspapers played up the brilliant coup of the police who had, as they said, now caught in their net "the dangerous *Républicain* Évariste Galois and had placed him where he could not start a revolution." Finding no valid charge against him the police accused him of illegally wearing his artillery uniform, even though the artillery had been disbanded. Nevertheless Galois was convicted and sentenced to imprisonment for six months. His sister, who saw him at this time, said he looked 50 years of age. It should be remarked that political prisoners were treated with reasonable kindness and, for them, the prison discipline was light.

The last letter he wrote was on May 29, 1832, and was addressed to all *Républicains*. On the margin of this letter he wrote these words: "I have not time, I have not time." History unfortunately does not say what happened to him, but what he wrote in those last hours before dawn will keep generations of mathematicians busy for centuries. The question he asked was: Under what conditions can an equation be solved by radicals? For the answer Galois employed his theory of groups. He was one of the great pioneers in this abstract theory which is of fundamental importance in all mathematics and many branches of physics, including quantum theory — and he was only 20.

Even in love Galois was unfortunate and perhaps also misguided. In this connection at an early hour on the morning of May 30, 1832, Galois fought a duel with pistols. He fell, shot through the intestines, and was left lying where he had fallen. A peasant who found him near what was then the Étang de la Glaciere on the territory of Gentilly, took him to the Cochin Hospital in Paris where he arrived still in possession of his faculties and before peritonitis set in. He refused the offices of a Catho-

(*Continued on page 338*)

designed for 5400 B/D operating at 6000 B/D



Lion Oil cat cracker accepted after 28 days initial run . . .

Typical of Lummus design, careful inspection, skilled construction and experienced operation is the performance of the catalytic cracker designed and built for Lion Oil Company, Eldorado, Arkansas.

This plant—the 31st Lummus catalytic cracking plant—went on stream September 16th. It not only met all guarantees but soon exceeded design capacity. It was accepted by Lion on October 13th after 28 days of continuous operation. On the 85th day of the initial run, the reactor was by-passed for the insertion of larger orifice plates to permit increased charge capacity. 6024 B/D of fresh gas oil charge have already been processed with a possible 7000 B/D in the near future—against a design capacity of 4500 B/D of fresh feed plus 900 B/D recycle. The unit has also exceeded the guaranteed percentage yield of high-octane gasoline and has produced 3070 barrels per day of 10 lb. RVP gasoline against a 2040 B/D guarantee.

Long initial runs have always been characteristic of Lummus plants. Among many outstanding initial runs is that of a Lummus catalytic cracking plant which ran 240 days before it was shut down for inspection.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas
LONDON—78 Mount Street, London, W. 1, England

The
RUMFORD PRESS
CONCORD
NEW HAMPSHIRE

WHERE
Printing
IS STILL A CRAFT

TRADITIONAL
SYMBOL
OF
DEPENDABILITY
AND
LOW
OPERATING
COST
SINCE
1889

Built by the
BATH IRON WORKS CORP.
Shipbuilders and Engineers
BATH, MAINE, U.S.A.
HULL NO. 284
1947

BUILDERS OF PRIVATE, COMMERCIAL AND NAVAL VESSELS

ÉVARISTE GALOIS

(*Continued from page 336*)

lic priest, perhaps remembering that the clergy was the cause of his father's death. His younger brother, who had been forewarned, arrived in tears. Galois comforted him with a show of bravery. "Don't cry," he said, "I need all my courage to die at twenty." Yes, this boy with somber face, abstemious habits, and perpetual air of concentration died when most youths just begin life — at 20.

Évariste Galois passed away on May 31, 1832, at 10:00 A.M. not having yet attained his twenty-first birthday. He was buried in the common grave of the South Cemetery of Paris where today no trace remains of even the charity-given grave which once held the body of one of France's mathematical luminaries. He willed to the world a rich and enduring monument in his collective works.

To his friend, Auguste Chevalier, Galois addressed his will which began: "My Dear Friend, I have made some new discoveries in analysis," which he outlined, concluding with the remark, "Ask Jacobi or Gauss publicly to give their opinion, not as to the truth but to the importance of these theorems. Later, there will be, I hope, some people who will find it to their advantage to decipher all this mess. *Je t'embrasse avec effusion*. E. Galois." In one of the letters to Chevalier was a résumé of the whole of his contributions to mathematics. That letter, fortunately, is preserved. It contains seven pages and is one of the most precious documents in the important science of mathematics.

Even now there are still many seeking "to decipher" what Galois dared to call "this mess." Too bad that he did not live longer for if he had, he would perhaps have left a greater mass of his golden "mess." Évariste Galois was right in saying that some people would find it to their advantage to decipher his rich heritage. Many are still picking nuggets from the vein of the mine he left behind. Galois' scientific executor, Joseph Liouville, in 1856 edited some of the manuscripts for the *Journal des Mathématiques Pures et Appliquées*. Singled out for special mention is the following gem from Liouville's comments: "My zeal was well rewarded, and I experienced an intense pleasure at the moment when, having filled in some slight gaps, I saw the complete correctness of the method by which Galois proves, in particular, this beautiful theorem: In order that an irreductible equation of prime degree be solvable by radicals it is necessary and sufficient that all its roots be rational functions of any two of them."

Perhaps the importance of Galois' work may be emphasized by stating that shortly after Galois' death, there appeared the following two important proofs, based on his work: (1) It is impossible to find formulas for the general fifth-degree equation similar to those which solve the quadratic equation, using only roots and elementary mathematical operations; (2) It is impossible to trisect an arbitrary angle by using only a compass and straight edge. The first of these important proofs was enunciated by Abel to whom Galois had been compared; the second by Wantzel.

Paul Dupuy in his *La Vie d'Évariste Galois* eulogizes him as follows: "At least the grave did not take him

(*Concluded on page 340*)

20-Year Record of Heating Comfort

Hecht Brothers Department Store, Baltimore, Md.
Heated by Webster Steam Heating System since 1927.

This is the 20th year of Webster heating service at Hecht Brothers Department Store in Baltimore, where management has long recognized that heating comfort is an important factor in successful department store operation.

In 1927, when the present home of Hecht Brothers Department Store was built, a Webster Vacuum System of Steam Heating was specified by Abbott, Merkt & Co., Inc., New York, Architects and Engineers. The installation included Webster Radiator Traps and Supply Valves, Webster Float and Thermostatic Traps and Dirt Strainers and a Nash Vacuum Pump. Riggs, Distler & Co., Inc., Baltimore, were the heating contractors.

In 1941, Hecht Brothers decided to discontinue their coal-burning boiler plant and purchase street steam from the Consolidated Gas Electric Light & Power Co. On the recommendation of the Gas & Electric Company, they decided to convert the installation to a Webster Moderator System, then as now recognized for comfort at low cost.

Installation of a 3-Valve E-4 Webster Moderator System, controlling 15,824 square feet of installed direct radiation, was completed during the heating season without interruption in store operations. Webster Radiator Valves were fitted with expertly sized Webster Metering Orifices so that all radiators would heat evenly. The existing piping was retained.

Hecht Brothers Store faces north. The heating installation is zoned to compensate for the sun effect by delivering proportionately more steam to the north side of the building. Radiators in sections of the store warmed by solar heat receive less steam. Steam savings are appreciable.

Since the introduction of district steam service, there has been a noticeable improvement in cleanliness, an important factor in department store operation. The dust, dirt and smoke which go with many private plants are avoided.

Sam Hecht, President of Hecht Stores, and William P. Calhoun, Store Manager, look upon their Webster Heating System as an investment in customer satisfaction. Webster Service is provided by Baltimore Representative H. M. Harris, with Webster for 18 years.

If you are interested in heating comfort at low cost backed by the experience of long-service Webster Representatives, give us a few facts about your heating requirements.

WARREN WEBSTER & CO., Camden, N. J.
Representatives in principal U. S. Cities :: Est. 1888
In Canada, Darling Brothers, Limited, Montreal

Webster
HEATING SYSTEMS

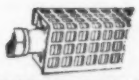
Webster Heating Equipment for Today's New Buildings

Webster Metering Orifices, expertly sized, a vital feature of the Moderator System, balance distribution and make possible central control with continuous heating.

Webster Outdoor Thermostat Control automatically provides the lowest pressure for comfortable inside temperature.

Webster Float and Thermostatic Drip Traps are used on heating coils of air conditioners and drip points of the piping system.

Prefabricated Unit—Webster System Radiation convectors with copper tubing, aluminum fins, integral Webster Traps and Valves.



New! Webster Type W1 Radiation for installation where floor or wall space is limited.

ÉVARISTE GALOIS

(*Concluded from page 338*)

entirely: the few pages which he left have sufficed that his country knows his name. His real country, the most beautiful and the grandest of all, the one in which those rigorous and profound conceptions necessarily fraternize, the world of Mathematics, all the noble intelligence of which is spread over the entire world. If, as he said, immortality is only a path left in the memory of men, he is assured of this immortality so long as man remains on earth. Unknown to the masses yet his name is secured against forgetfulness by the admiration of an elite. It is for these that I have written this study, in wishing to add to my admiration of the genius, my sympathy for his passionate soul, the racked and tormented heart and finally to erect alongside of his name, which represented but ideas, the living figure of a man."

The world owes a debt to Monsieur Dupuy for having brought to life the boy and man Galois. Our own praise and appreciation of Galois may be summed up as follows: The miner has disappeared but the rich mine which he uncovered and worked all his life he left not to his country alone but to the world. Men who have carried the swords of war have been knighted and raised on high pedestals of fame. Should we not, at least, do something to commemorate the name of him who brought us the key called mathematics which opens the portals to all of man's exact knowledge?

It would certainly be paying a fitting tribute to erect in the court of the École Polytechnique in Paris a monument on which should be inscribed this simple text:

Évariste Galois
Mathématicien de Génie
1811–1832

BIBLIOGRAPHY

Annales Scientifiques de l'École Normale Supérieure, 3eme Série, Volume 13, 1896. The life of Galois is given in this publication, written by P. Dupuy, with notes edited by Jules Tannery. The entire text of this original contribution in the *Annales* is reprinted in *Cahiers de la Quinzaine*, October 27, 1903, pages 5–104.

Davidson, Gustav, "The Most Tragic Story in the Annals of Mathematics; The Life of Évariste Galois," *Scripta Mathematica*, June, 1939, VI: 2, pages 95–100.

Emil, Artin, Lectures given at the University of Notre Dame.

Milgram, Arthur N., Mathematical lectures, second edition, supplement. (Ann Arbor, Mich.: Edwards Brothers, Inc., 1942.)

Carlitz, Leonard, *Galois Fields of Certain Types*. (Philadelphia, Pa.: University of Pennsylvania [thesis], 1930.)

Dehn, Edgar, *Algebraic Equations; An Introduction to the Theories of Lagrange and Galois*. (New York: Columbia University Press, 1930), $4.25.

Dickson, Leonard E., *Theory of Algebraic Equations*. (New York: John Wiley and Sons, 1903.)

Mathews, George B., *Algebraic Equations*. (Cambridge, England: Cambridge University Press, 1930.)

Bell, Eric T., *Men of Mathematics*. (New York: Simon and Schuster, 1937), $5.00.

Fink, Karl, *A Brief History of Mathematics*. Translated in English by Wooster Woodruff Beman and David Eugene Smith, 1910. (LaSalle, Ill.: Open Court Publishing Company), $1.50.

Steinitz, Ernst, *Algebraische Theorie der Körper*. (Berlin, Germany: de Gruyter, 1930.)

Doelcam Corporation

PRECISION INSTRUMENTS

GYROSCOPES — GYROSCOPIC DEVICES

DESIGN • DEVELOPMENT • PRODUCTION

56 ELMWOOD STREET, NEWTON 58, MASS.

HAROLD J. RYAN, INC.

Air Conditioning

101 PARK AVENUE NEW YORK 17, N. Y.

Industries Served by TAFT-PEIRCE:

7. MACHINE TOOLS

THE TAFT-PEIRCE MFG. CO.

Contractors for the Manufacture of Machines

AND MECHANICAL SPECIALTIES WITH PARTS INTERCHANGEABLE

Estimates Furnished for Special Tools & Mfre.

SPECIAL ATTENTION GIVEN TO THE DESIGNING OF MACHINES FOR ECONOMICAL MANUFACTURE

(FROM WOONSOCKET CITY DIRECTORY, 1900)

...and we can say this again in 1948!

It's natural enough that machine tool builders always have been important clients of Taft-Peirce. For most of them know that T-P has banked the longest and broadest experience of any concern in the country devoting a major part of its activities to the contract design and manufacture of tools and special machinery.

Many of them, indeed, think of T-P as their own design department and their own tool room. Many a world-famed machine tool is shipped f.o.b. builder's plant, equipped with jigs, fixtures, and cutting tools, T-P designed or T-P built, or both.

More than one well-known machine tool has had its origin here, too—built on contract to T-P designs, or to the machine tool builder's own. Taft-Peirce has designed a long list of machines for its own needs, too, some of which, at the insistent suggestion of customers familiar with this versatile plant, have found their way into the open market as units of T-P's own machine tool line—machines such as surface grinders, back spot facing machines, and a new spline and gear grinder.

The design and manufacture of special machinery and tools always will be the business of the Taft-Peirce Contract Division. What is more, the T-P trade-mark always will certify "Top Precision" in this field of work. No job is too small; none is too large. Ask for a copy of our contract service bulletin entitled, "Take It to Taft-Peirce." Address: The Taft-Peirce Manufacturing Co., Woonsocket, R. I.

For Engineering, Tooling, Contract Manufacturing

T-P

TAKE IT TO TAFT-PEIRCE

No charge for Style!

Rogers Peet Clothes

The style-authority of the *modern* Rogers Peet goes into every suit and topcoat we make.

This authoritative smartness costs you nothing.

Well-dressed men have always recognized the *value* they get in our kind of woolens and tailoring.

To try on a Rogers Peet suit or topcoat is to sense what men mean when they say: "*Feels* as right as it *looks*."

Styles for young men, and men who never grow old.

Rogers Peet Company

Makers of Fine Clothes

In New York: Fifth Avenue *at* 41st Street | Thirteenth St. *at* Broadway | Warren Street *at* Broadway | *And in Boston:* Tremont St. *at* Bromfield St.

WHAT'S ON THE WORKER'S MIND?

(*Continued from page 324*)

World War I is still relevant: "It is impossible to help wondering if the unions would have grown to anything like their present size if all the managers who find them so serious a problem had felt more seriously how keenly this problem of the daily job touches the life and soul of the worker."

The union movement has come to assume the fundamental importance in the eyes of the worker which attaches to the job itself. This sense of the significance of the union arises, of course, from the fact that it is intended to serve as a job-security device.

The polls show a willingness among workers to endorse unions, although such support is qualified. In the winter of 1942 Roper submitted a check list of two positive and two negative statements. Three-fourths of the union members checked statements indicating they would give unions more power or would support them despite their mistakes, while nonunion workers were divided rather closely (42.7 per cent and 48.4 per cent) on the positive and negative propositions respectively. In May, 1942, Gallup formulated the categoric question: "Are you in favor of labor unions?" Nationally, two out of three people in the United States said "yes." Among the workers, the skilled workmen's percentage of "yes" answers was 75; that of the unskilled, 71.

Union Support Qualified

Despite this willingness to back unions, American workers qualify their support of unions in many ways. In the late spring of 1940 Roper found that a few workers (7.0 per cent) thought that all unions are headed by persons with purely selfish motives. But a third (34 per cent) of the workers said that some unions are so led, one-eighth (13 per cent) believed that about one-half of the unions are, and one-fifth (20 per cent) of the workers felt that most unions are selfishly administered. The statistical summaries of the poll data follow this same pattern of differentiated responses to questions about the efficiency and honesty of union management, about the manner in which unions keep their promises, about the use of threats of violence in gaining members. Worker opinion is divided, and so is union opinion, apparently, on these issues. A similar split appears in the statistical tables setting forth responses to questions concerning union tactics. On the basis of polls conducted in June, 1940, June, 1941, August, 1945, and November, 1946, the reports of the Roper and Gallup agencies display a lack of uniformity. In fact, there is evidence of a wider scatter

(*Continued on page 344*)

BIG GAME HUNTING

NORTHWESTERN WYOMING

Elk — Deer — Moose — Bear
Mountain Sheep

Early arrangements necessary. Moose and sheep licenses must be applied for before July 1st.

SUMMER ACCOMMODATIONS FOR FAMILIES

Trout Fishing *Pack Trips*

T CROSS RANCH

ROBERT S. COX, '12 DUBOIS, WYOMING

If You're Planning a Trip
Make Your Plans Complete

Let us take care of your investments while you are away. As Custodian of your securities, we will collect bond coupons and dividends from stock, depositing them in accordance with your instructions; also execute your orders to purchase or sell investments charging or crediting your account here.

Protect your valuable papers, jewelry and important documents in your private Safe Deposit box in our vaults. Silver and other bulky valuables may also be stored conveniently and safely in the vaults at our Back Bay Branch.

Let us arrange for your Letter of Credit, and provide you with Travelers Checks, in denominations of $10 to $100, which may be cashed almost anywhere. You will be reimbursed for them if they are lost or stolen.

The

New England Trust Company

135 DEVONSHIRE STREET

At the Corner of Milk Street

BACK BAY BRANCH : : 99 NEWBURY STREET

BOSTON, MASS.

Member Federal Deposit Insurance Corporation

A Report

TO M.I.T. MEN

In 1917 Walker Memorial Building was opened, a gift from Alumni for the welfare of M.I.T. students. In addition to including offices for student activities and serving as a student social center, this building houses the dining service.

In 1946–47 nearly one million meals were served to staff and students. Morss Hall seats approximately 500 people. Thus, each chair served 2,000 people per year or 5.5 persons per day. We thank the Alumni for making these services possible.

WALKER MEMORIAL DINING SERVICE

• *M.I.T.* •

CAMBRIDGE 39, MASSACHUSETTS

A. W. BRIDGES, *Manager*

To all Chevrolet, Plymouth, Ford, Chrysler and Dodge Owners —

ASK YOUR DEALER ABOUT THE

VENTALARM®

FIL·GARD*

Three NECESSITIES in one ACCESSORY

1. Separate Vent
2. Anti-Theft Baffle
3. VENTALARM ® FILL SIGNAL

*T. M. REG.

SCULLY SIGNAL COMPANY

Cambridge 41, Massachusetts

WHAT'S ON THE WORKER'S MIND?

(*Continued from page 342*)

of opinions on such matters as picketing, union dues, denial of work in a time of strike, strikebreaking, closed shop, and work-restriction practices.

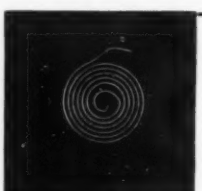
Nevertheless, in the poll data on questions of economic advantage — for example, working hours, wages, and working conditions — the union workman appears to be a typical economic man and willingly supports leaders and organizations which promise to protect his immediate economic welfare. To the question, asked by Gallup in the winter of 1946, whether or not the demand of labor leaders for a wage increase of 20 per cent was in line with the costs of living, a characteristic response was made. Of labor union members five-eighths (62 per cent) of them agreed that the increased wage demands were justified. In spite of any reservations they might want to make concerning union management and tactics the immediate, if not the long-range, gains for the job which the union promotes and protects seem to lead workers to prefer employment where a union exists.

Labor Views the State

Tradition among American laborers calls for opposition to government interference in industry: at least it did until the factors associated with the New Deal and the rise of the Congress of Industrial Organizations made their appearance. The older tradition of noninterference is not completely dead, for it manifests itself in certain attitudes expressed in the public polls. But on the whole, American labor seems to have broken with tradition and now looks to the state rather than the group for solutions to its problems.

Like many other American citizens, the workers appear to have cast aside self-restraint and discipline in favor of a law which will do this, or a law which will prevent that. Thus, Gallup announced in June, 1944, that labor sentiment was in favor (64 per cent) of a law to prevent strikes in war industries. In the late spring of 1941 Roper found labor ready (68 per cent) to support a government agency with the power to force settlement of differences between employers and employees. In the fall of 1946, according to Roper, a third of American unionists approved a do-nothing policy (aside from preventing violence) in a specified labor dispute, 28 per cent approved of "friendly offices" overtures by government, and a third sanctioned arbitration or intervention. These samples are excellent indices of the manner in which labor is willing to support laws, even those controlling collective

(*Continued on page 346*)



PRECISION-GAUGED HAIRSPRINGS AND FINE ROLLED WIRE

PRECISION PRODUCTS COMPANY

WALTHAM, MASSACHUSETTS

ROBERT I. BRADLEY '20

"IT'S FROM BROOKS BROTHERS' SIXTH FLOOR SHOP"

We have planned Brooks Brothers' Sixth Floor Shop for men who like Brooks Quality and Good Taste in the Things they wear. Here men find a complete line of Suits, Shirts and Neckties...and other Clothing and Furnishings that fill their every requirement. Things that are typically Brooks...at generally lower prices.

Suits, $70 *to* $85 • *Shirts*, $4.25 *and* $5

Neckwear, $1.50 *to* $2.50 • *Pajamas*, $5 *and* $6

ESTABLISHED 1818

Brooks Brothers
CLOTHING
Men's Furnishings, Hats & Shoes

346 MADISON AVENUE, COR. 44TH ST., NEW YORK 17, N. Y.
111 BROADWAY, NEW YORK 6, N. Y.

46 NEWBURY STREET,
BOSTON 16, MASS.

727 WEST SEVENTH ST.,
LOS ANGELES 14, CALIF.

165 POST STREET,
SAN FRANCISCO 8, CALIF.

THE TRIAL IS NEVER OVER

***GOOD-WILL** is the disposition of the customer to return to the place where he has been served well—*

U. S. Supreme Court.

TO OUR FRIENDS

We do not believe that any advertising copy man could have penned a neater and more trenchant definition than this decision of the Supreme Court.

It happens also to be the verdict which our customers have reached regarding their relations with us.

Your specific problems in technical reproduction work from the lowly blue print to the complicated offset printing of an engineering manual, will find their happy solution with us.

ELECTRO SUN COMPANY, INC.

Blue Prints — Photo Prints — Photo Offset

161 Washington Street **157 Chambers Street**
Grand Central Terminal Building
NEW YORK, N. Y.

A. L. Weil '01 **J. C. Duff '86**

THE MURRAY PRINTING COMPANY

A Complete Printing Organization
Letterpress :: Offset :: Binding

18 AMES STREET
CAMBRIDGE

MEN'S CLOTHING *of* EXCELLENT QUALITY

SUITS

Worsteds Flannels
Tweeds Gabardines

$45.00 to $70.00

TOPCOATS

Gabardines Coverts
Tweeds

$45.00 to $77.50

Selected from the lines of

BOTANY 500 JOSEPH & FEISS
MICHAELS STERN WORSTED-TEX

Patronage Refund to Members

The COOP

Harvard Square Store

WHAT'S ON THE WORKER'S MIND?

(*Continued from page 344*)

bargaining situations. They also bring out the traditional reserve with which the American laboring population regards its government.

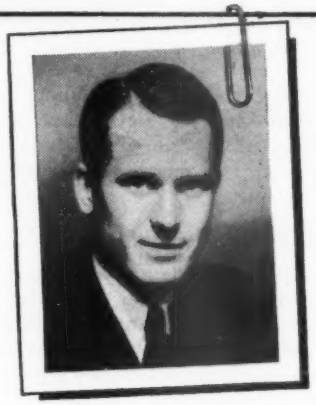
Like most Americans, however, the workers are aware of the importance of bringing pressure on government for desired ends, and they have definite feelings as to who brings pressure. Roper inquired, in the fall of 1946, as to what group puts the most pressure on Congress to get what it wants. Labor unionists thought that businessmen do, and businessmen, of course, thought that labor does. Characteristically enough, each side felt that Congress pays more attention to the other side. The scramble for government assistance is certainly a part of labor — and general public — ideology; but the various groups in the American public are apprehensive, and jealous, of the amount of aid being given the respective claimants by government.

Labor Unions in Politics

Two out of three factory workers (68.2 per cent) told Roper representatives in the winter of 1943 that they thought "our form of government works well and only a few changes, if any, should be made in it." A fourth of them checked a statement that "it needs to be thoroughly revised to meet present-day conditions." American unionists have long held a policy of no political participation, other than rewarding friends and punishing enemies at election time. This view is still strong. Roper's field men were advised by more than one-third (37.7 per cent) of all union members that labor unions should stay out of politics. On the other hand, more than one-fourth (29.9 per cent) said that unions should support major political parties. Only one union member in five supported the formation of a labor party, though members of the American Federation of Labor and the Congress of Industrial Organizations differed on this issue.

This withdrawal attitude, sometimes labeled Gomperism, applies only to politics, however, and not to the scope and activity of the government itself. For example, the American Leadership Panel sought to know what labor responses would be to the question: "Whom do you hold primarily responsible for assuring job opportunities to returning veterans?" In two-thirds (64.4 per cent) of the interviews, labor told Panel representatives that government should assume this responsibility. Like many other American citizens, workers in this country seem to favor a positive state program. Thus according to a poll made by Gallup in the fall of 1945, slightly more than half of them (52 per cent) believe in a law requiring employers to hire a qualified person, regardless of race or color; no other group polled showed so high a percentage. In the winter of 1945 the National Opinion Research Center discovered that 65 per cent of the workers — protective, personal, manual, and skilled — would like to see government decide what is a fair profit for big business. A smaller percentage (53 per cent) felt the same way about small business. As in so many proposals touching directly on economic gains, the wage earners in this country informed Gallup in the summer of 1945 that they would favor making the minimum wage $0.65 an hour for all workers in business and industry.

(*Continued on page 348*)



WILLIAM B. JADDEN—LOS ANGELES, CALIFORNIA

Another post-college career story

Two months before my release to inactive duty from the Navy, I began to think seriously about a peacetime career. I had a Master's degree in business administration, and almost four years of supervisory experience with a leading aircraft concern in Los Angeles. But I realized that going back to the aircraft company might mean the same kind of seniority drawbacks as in the Navy, and my earnings wouldn't necessarily be in direct proportion to the work I put in. Besides, the idea of working for myself appealed to me more strongly than ever.

My first thought was to start a business of my own. But that would take a much larger investment than I could possibly make.

About this time I recalled some New England Mutual advertisements I had read in the Princeton Alumni Weekly, which reached me regularly overseas. I began to ask myself whether life insurance wouldn't give me more than just another job. So I wrote the New England, and several other companies, for more information. The more I looked into it, the more I liked the idea of this business.

When I got back to Los Angeles as a civilian, I called on the agencies of the six companies I regarded as tops in the field. I began a very lengthy analysis of the pros and cons of going into the business. My investigation convinced me that life insurance offered just about everything I was looking for--something in which I'd be my own master without making a heavy investment, where hard work couldn't help but increase my earnings, and where I'd never have to ask for a raise. I became convinced, too, that the New England Mutual was the Tiffany of life insurance companies.

I took the aptitude test, then basic training here in our agency, followed by a comprehensive course* at the Home Office in Boston. Now, after qualifying for membership in the Company's Leaders Association in my first year, I can definitely say that I am happy I made this choice. The proof, I think, is that I have never once had the well-known feeling that "the grass is greener on the other side of the fence."

J K L

*Graduates of our Home Office training courses, many of them new to the business, are selling at a rate which produces average first-year incomes of $3600. The total yearly income on such sales, with renewal commissions added, will average $5700.

Facts such as these helped Bill Jadden solve his career problem. If you'd like to know more, write Mr. H. C. Chaney, Director of Agencies, New England Mutual Life Insurance Company, 501 Boylston Street, Boston 17, Massachusetts.

Here are some of the M. I. T. men now with New England Mutual:

Raymond P. Miller, '18, Salem
Blaylock Atherton, '24, Nashua
Arthur C. Kenison, '19, Boston
Leland S. Person, '34, Rutland

We have opportunities for more M. I. T. men. Write Dept. X.

WILLIAM D. NEUBERG CO., INC.

Chemicals

GRAYBAR BUILDING 420 LEXINGTON AVE.
NEW YORK 17, N. Y.
TELEPHONE LEXINGTON 2-3324
CABLE—"WILNEUBERG"

J. C. CORRIGAN CO., INC.
Conveyers

Engineers • Manufacturers • Erectors
Coal Handling Systems
Materials Handling Equipment
Portable Conveyors

Distributors for
Jeffrey Manufacturing Co.
Jeffrey Parts Carried in Boston Stock

41 Norwood Street, Boston 22, Mass.
Tel. GENeva 0800

Transits and Levels are used on all largest works and by U. S. Govt. for utmost precision. Rental Insts. *New catalog, just issued, sent gratis. A souvenir plumb-bob sent for 3¢ postage.*

BUFF & BUFF CO. Boston 30, Mass.
Henry A. Buff '05

William H. Coburn, '11 William F. Dean, '17

William H. Coburn & Co.

INVESTMENT COUNSEL

68 Devonshire St. Boston, Mass.

WHAT'S ON THE WORKER'S MIND?

(*Continued from page 346*)

Almost 30 years ago, Whiting Williams noted among American workingmen "a conviction that, for them, there is no chance to break through on the industrial sector." The turn to the state in recent years is unquestionably related to this feeling.

The Security Motive

It would be useless to pretend that the polls tell us completely and accurately what's on the worker's mind, any more than does this résumé. Any person's claim to such information is obviously very dubious. In an age of machined and mass communication *vox populi* has become a rather meaningless phrase.

Williams came back from his own opinion survey with the overwhelming sense that the problem of security loomed large and menacing in the postwar America of his day, most of all among industrial workers. It still does.

In August, 1946, Gallup asked: "Do you think that there will be a serious business depression in the United States within the next ten years?" Among the general public the affirmative answers amounted to 60 per cent; among the manual workers, 56 per cent.

In the winter of 1942 Roper presented workers with the choice of selecting one of three different kinds of jobs. A job that pays quite a low income but which one might be sure of keeping attracted 55 per cent of the factory workers and 67.2 per cent of the personal service workers. Only 15.2 per cent of the former and eight and three-tenths per cent of the latter preferred a job that pays an extremely high income if one makes the grade but in which one loses almost everything if he does not make it. There was little difference between the choice of factory workers in general and that of union members. Low-paid security jobs appealed to southern Negroes (83.3 per cent), low-salaried workers (68.3 per cent), workers preferring employment with a small rather than with a medium-sized company, and the uninformed workers.

A definite pessimism pervades the ranks of American labor about security by means of their jobs. In the spring of 1947 Roper found that factory workers had mixed emotions about their ability to retire in reasonable comfort when they become 65 years of age. Four out of ten (42 per cent) thought it "likely" and four out of ten (41 per cent) also thought it "unlikely" that they would be able to do so. Pessimism was greater among Negro (48 per

(*Concluded on page 350*)

Boit, Dalton & Church

INSURANCE SINCE 1865

89 BROAD STREET, BOSTON 10 • *Telephone* HUbbard 2–3100

FREDERIC C. CHURCH CHAS. COLBY HEWITT JOHN W. GAHAN
FREDERICK G. FARQUHAR COLLINS GRAHAM STANLEY H. KING

McCREERY and THERIAULT

Building Construction

126 NEWBURY STREET BOSTON, MASS.

Lord Electric Company

INCORPORATED

ELECTRICAL CONSTRUCTION

131 Clarendon Street
Boston 16, Massachusetts
Telephone CO 6-0456

10 Rockefeller Plaza
New York 20, N. Y.
Telephone CI 6-8000

1201 Plaza Building
Pittsburgh 19, Pa.
Telephone COURT 1920

The TREDENNICK-BILLINGS CO.

*CONSTRUCTION ENGINEERS * BUILDING CONSTRUCTION*

K. W. RICHARDS '07 H. D. BILLINGS '10 C. C. JONES '12 F. J. CONTI '34

10 HIGH STREET * BOSTON, MASSACHUSETTS

If It's Made — Ask ALBERT!

FOR IMMEDIATE DELIVERY
Odd and Large Sizes a Specialty
⅛" to 72"
LARGEST AND MOST COMPLETE STOCK on Atlantic Seaboard
Our Own Shop Facilities for Bending — Coiling — Welding — Threading and Testing —
Meeting All Standard Specifications
TUBE-TURNS, WELDING FITTINGS AND FLANGES

• PIPE	• VALVES	• FITTINGS	• PILING
Electric Weld	Iron Body	Welding	ARMCO
Seamless	Forged Steel	Tube Turns	Youngstown
Spiral Weld	Cast Steel	Fabricated	Pile Points
Lap Weld	and	Cast Iron	Cobi-Pile Tips
Butt Weld	Special	Forged Steel	Pile Sleeves
Steel—Wrought Iron	Alloys	Dresser	Cobi-Timber Tips
Corrugated Culvert		Victaulic	

STAINLESS STEEL PIPE, FITTINGS AND VALVES

S. G. ALBERT '29, *Treasurer*

ALBERT PIPE SUPPLY CO., Inc.

No. 13th & Berry Streets, Brooklyn, N. Y. EVergreen 7-8100

EDGERTON, GERMESHAUSEN & GRIER, Inc.
Consulting Engineers
Research, Development and Manufacture
of Electronic and Stroboscopic Equipment
Specialists in High-Speed Photography
155 Massachusetts Avenue, Cambridge 39, Mass.

LEONARD CONSTRUCTION COMPANY
Engineers and Contractors
SINCE 1905
IN ALL THE AMERICAS AND FAR EAST
37 South Wabash Ave. Chicago
420 Lexington Ave. New York City

SWISS AUTOMATICS
Rebuilding and Tooling Service
We have trained personnel and facilities for complete rebuilding and tooling of your Swiss Automatics and other type Swiss Machines.
YOUR INQUIRIES ARE INVITED
BORIS M. VOLYNSKY MFG. CO., INC.
311 West 66th Street New York 23, N. Y.

WHAT'S ON THE WORKER'S MIND?

(Concluded from page 348)

cent) than among white workers (41 per cent). As might be expected, those workers over 40 were less confident than those under 40 years of age. C.I.O. unionists were less certain (35 per cent) than A.F.L. members (45 per cent).

The Roper poll in the winter of 1942 revealed a marked tendency among factory men (54.2 per cent) and factory women (46.2 per cent) to stay in the industry in which they were employed during the next five years. Only one out of ten expected to go into business for himself, and two and two-fifths per cent anticipated a change into "some kind of white-collar job." Five years later Roper asked: "Do you think the years ahead seem to hold for you personally a good chance for advancement?" Factory workers and union members divided rather evenly on the question. The former group said, in 47.7 per cent of the interviews, that they had a good chance, in 40.7 per cent that they saw little improvement over their present position. The percentages for union members were 48.7 and 41.2.

According to the polls, American workingmen are not prepared as yet, however, to accept the doctrine of the maturity of the American economy. In November, 1939, they were asked by Roper whether they believed: "(1) that the great age of economic opportunity and expansion in the United States is over? or (2) that American industry can create a comparable expansion and opportunity in the future." Factory workers were less confident (69.6 per cent) of expansion than the general public (71.7 per cent), but both obviously had great expectations and were unwilling to accept the maturity thesis.

Perhaps behind this optimism lies the recognition that "the thread of self-respect and standings and statuses," as Whiting Williams put it, "ties the world of modern society together," and that this thread is bound securely to the prospect and realization of social and economic improvement. "The main thing," wrote Williams, "is the sense of motion and progress."

SYSKA & HENNESSY, Inc.
Engineers
Consultation Plans Reports
Power Plant Disposal Plants
Water Systems
NEW YORK, N. Y.
J. F. HENNESSY '24

N. A. LOUGEE & COMPANY
ENGINEERS
Successors to J. H. Manning & Company
Reports — Appraisals — Depreciation Studies
Rate Cases — Business and Economic Studies
120 BROADWAY NEW YORK
N. A. LOUGEE '11 L. H. MATTHEWS '13
J. W. MCDONALD, JR. '20

PREPARATORY SCHOOLS FOR BOYS

CHAUNCY HALL SCHOOL
Founded 1828. The School that specializes in the preparation of students for the Massachusetts Institute of Technology.
Ray D. Farnsworth, *Principal* 553 Boylston Street, *Boston, Mass.*

HUNTINGTON SCHOOL FOR BOYS
Grades Nine to Twelve.
Thorough preparation for entrance to M.I.T. and other technical schools.
Regular and summer courses.
William G. Wilkinson, Headmaster
320 Huntington Ave., Boston Tel. Kenmore 1800

PROFESSIONAL CARDS

JACKSON & MORELAND
Engineers and Consultants

Design and Supervision of Construction
Reports — Examinations — Appraisals
Machine Design — Technical Publications

BOSTON NEW YORK

H. K. BARROWS, '95
M. Am. Soc. C. E.

CONSULTING HYDRAULIC ENGINEER

Hydro-electric Developments — Water Supplies. Reports, Plans, Supervision. Advice, Appraisals

6 Beacon Street Boston, Mass.

Eadie, Freund and Campbell
Consulting Engineers

500 Fifth Avenue New York 18, N. Y.

Plans and Specifications — Examinations and Reports

Power, Heating, Ventilating, Electric, Plumbing, Sprinkler, Refrigerating, Elevator Installations, etc., in Buildings and Industrial Plants

J. K. Campbell, M. I. T. '11

STARKWEATHER ENGINEERING CO.
INCORPORATED

Engineers and Contractors for Pumping Plants Boiler and Power Plants, Cooling Water and Heat Recovery Systems

246 Walnut Street, Newtonville BIGelow 8042

Wm. G. Starkweather, M.E. Cornell '92 — J. B. Starkweather, B.S. M.I.T. '21

THE KULJIAN CORPORATION
Consultants • Engineers • Constructors

Specialists in
UTILITY, INDUSTRIAL and CHEMICAL FIELDS

1518 Walnut Street Philadelphia, Pa.

H. A. Kuljian '19

FABRIC RESEARCH LABORATORIES
INCORPORATED

Research, Development and Consultation for Textile and Allied Industries

665 Boylston Street Boston, Mass.

W. J. Hamburger, '21 K. R. Fox, '40 E. R. Kaswell, '39

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

Malcolm G. Davis '25, *Vice President* Allen W. Reid '12 E. C. Edgar '35

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York, N. Y. Reading, Pa. — Washington, D. C. Philadelphia, Pa.

FAY, SPOFFORD & THORNDIKE
Engineers

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

Boston New York

WALLACE CLARK & COMPANY
MANAGEMENT CONSULTANTS

Since 1920

Planning for Research and Development, Engineering, Production, Quality Control, Maintenance, Surveys, Industrial Relations, Sales, Management Audits.

521 Fifth Avenue New York 17, N. Y.

MAURICE A. REIDY
Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

THE COSMA LABORATORIES CO.

1545 East 18th Street Cleveland 14, Ohio

Chemical Analysis — Testing — Consulting Engineering
Testimony and Research

H. Seymour Colton, M.I.T. '21, *Director* — R. W. Frischmuth, Case '38, *Assistant Director*

Moran, Proctor, Freeman & Mueser
Consulting Engineers

420 Lexington Avenue New York 17, N. Y.

Foundations for Buildings, Bridges and Dams; Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

Pardo, Proctor, Freeman & Mueser
Ingenieros Consultores
Ap. Correos 614, Caracas, Venezuela

William H. Mueser, '22
George T. Gilman, '23

William W. Russell '22 Edgar P. Palmer '25

PALMER RUSSELL CO., *Realtors*

1320 Beacon Street Brookline 46, Massachusetts

Complete Mortgage Service

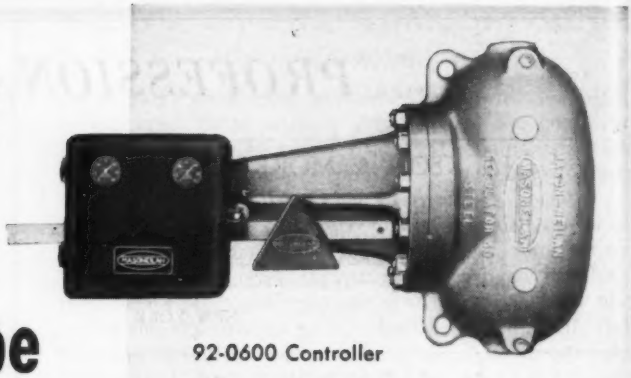
Business Loans to Corporations and Institutions
Loan Correspondent for the Penn Mutual Life Insurance Company

FAirmount 5105 EXpress 7766

FRANK MASSA
Electro-Acoustic Consultant

3393 Dellwood Road 3868 Carnegie Avenue
CLEVELAND, OHIO

NEW



92-0600 Controller

Instrument-Type
Ball Float Level Controllers

The ball float level controller still has a place in process control. Although level measurement by displacement has overshadowed the ball float type of measurement, there are many applications where, because of the nature of the liquid and/or operating conditions and/or physical limitations, measurement of level by ball float is the only practical solution.

Recognizing the many advanced features of the 12000 Series (displacement type) instruments, Mason-Neilan now offers you these features in combination with flange, chamber and shaft type ball float level controllers.

The highly responsive control mechanisms give

Proportional Control

Proportional-Reset Control

Remote Pneumatic Transmission

Duplex Control or Duplex Controller-Transmitter

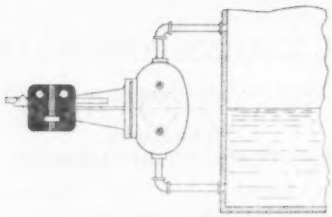
These are the same mechanisms used on our 12000 Series displacement type level controllers.

Simple, foolproof adjustment of proportional band setting over a wide calibrated range. Easy control point setting by vernier knob with indicating scale.

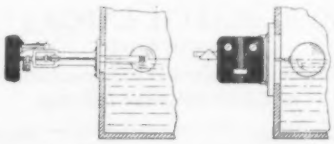
All assemblies are weatherproof, compact, and rugged.

Consult Our Nearest Office

Interior View of Instrument



Chamber Type



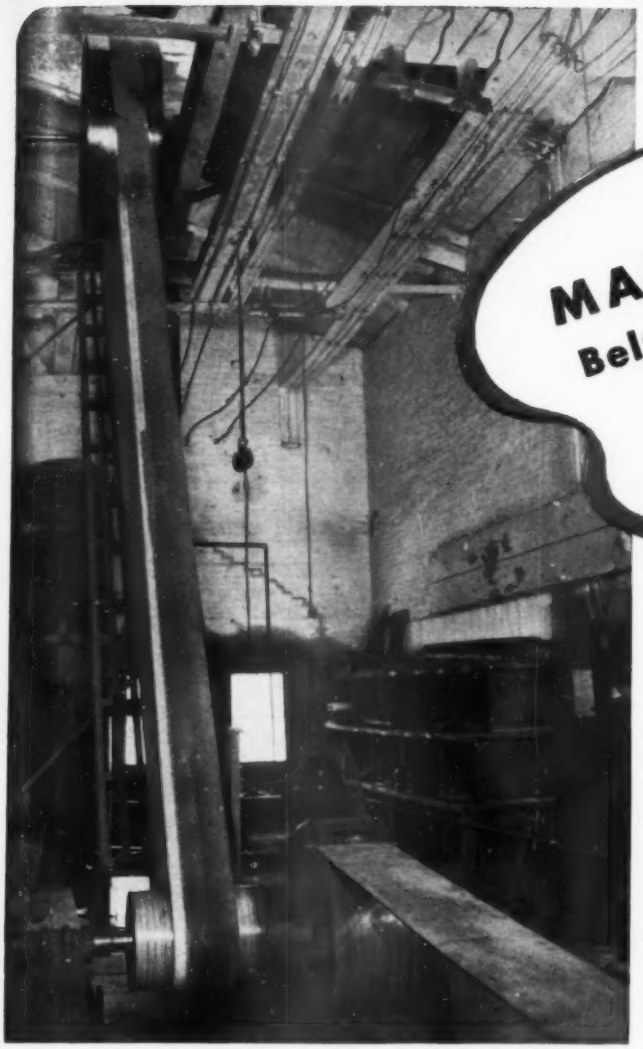
Shaft Type Flange Type

MASONEILAN

MASON-NEILAN REGULATOR COMPANY

1190 ADAMS STREET, BOSTON 24, MASS., U. S. A.

New York • Buffalo • Chicago • St. Louis • Philadelphia • Houston • Pittsburgh • Cleveland • Tulsa • Atlanta • Denver
Cincinnati • Los Angeles • San Francisco • Mason Regulator Company of Canada, Ltd., Montreal and Toronto



This MANHATTAN Belt . . . gave 22 years continuous service

. . . traveled 1,448,864 miles

The 18-inch, 5-ply Manhattan Transmission Belt pictured here was held in storage over 4 years, followed by *22 years* of actual service. It operated a line shaft in the machine shop of the Huntington and Broad Top Mountain Railroad and Coal Company. This drive is nearly vertical which means that a higher than normal belt tension had to be maintained to prevent slip.

We quote directly from a letter from Mr. F. E. Steele, Superintendent:

> "It is my personal opinion that this is a remarkable service for a belt of this type when we take into consideration the fact that drive pulley was 14 inches in diameter. This within itself would throw considerable strain on a belt of this width and weight, also with a speed of approximately 2,383 feet per minute. During this period of operation we had no trouble whatsoever and at all times the belt worked very satisfactorily."

A lacer accident finally ended its career.

> "Should this accident not have happened, the belt would still be in service and doing a good job."

This is one of many case histories to which Manhattan can point for proof of Workmanship and Quality Materials . . . reasons why Manhattan has long been famous for its belts. Whatever the job, there's a Manhattan Belt that will lower *your* costs, too.

A SINGLE SOURCE for a COMPLETE BELTING LINE

Manhattan offers a range of four driving tension surfaces on rubber transmission belts. Also Endless Cord, Non-Spark, Oil-Proof and Acid-Proof constructions. Belts can be factory-made endless or field vulcanized by the Condor-Weld method. All Manhattan endless belts have the patented Extensible-Tip outer-ply splice which prolongs belt life considerably. Literature on request.

RAYBESTOS R M MANHATTAN

RAYBESTOS-MANHATTAN INC.

Keep Ahead with Manhattan

MANHATTAN RUBBER DIVISION **PASSAIC, NEW JERSEY**

Thomas H. Boyd, '23 Wilder E. Perkins, '25 Charles P. McHugh, '26 Daniel J. Hanlon, '37 Albert W. Beucker, '40

NEW AUDIO *and* SUPERSONIC OSCILLATOR

with Low Distortion • Uniform Output • High Stability

THIS new wide-range, continuously adjustable oscillator was designed to fill a need for an instrument for laboratory measurements of gain, distortion, impedance and frequency response at frequencies well above the audio range.

With a single dial and four push-button-controlled multipliers, the Type 1302-A Oscillator covers the range of 10 to 100,000 cycles. Because of its wide frequency range and flat output this oscillator is particularly suited to taking frequency response characteristics on amplifiers, telephone lines, filters and other such circuit elements.

FEATURES

- **WIDE FREQUENCY RANGE** — 10 to 100,000 cycles — 180-degree rotation of dial covers the 10 to 100-cycle decade — panel push buttons add in decade steps
- **ACCURATE CALIBRATION** — adjusted within ($\pm$ 1½% + 0.2 cycle
- **LOW DISTORTION** — less than 1% at any frequency
- **SMALL FREQUENCY DRIFT** — less than 1% in first 10 minutes; less than 0.2% per hour afterwards
- **FREQUENCY DRIFT CONSTANT PERCENTAGE OF OPERATING FREQUENCY** — particularly helpful with bridge measurements at low frequencies
- **CONSTANT OUTPUT VOLTAGE** — within $\pm$1.0 db over whole range; 20 volts open circuit on 5,000-ohm output, 10 volts on 600 ohm
- **STABILIZED SUPPLY** — compensated for transient line voltage surges and average line voltage variations between 105 and 125 (210 and 250) volts
- **VARIABLE CONDENSER FREQUENCY CONTROL** — avoiding contact difficulties often found in variable resistance control
- **TWO SEPARATE OUTPUT CIRCUITS** — balanced 600 ohm and unbalanced 5,000 ohm

TYPE 1302-A OSCILLATOR · · · $365.00

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 | 920 S. Michigan Ave., Chicago 5 | 950 N. Highland Ave., Los Angeles 38